# SCENARIO OUTLOOK AND ADEQUACY FORECAST 2013 2030

European Network of
Transmission System Operators
for Electricity

entsoe

# Content

# 1 EXECUTIVE SUMMARY

The Scenario Outlook & Adequacy Forecast (SO&AF) is the ENTSO-E annual publication, and presents the Scenarios included in the Ten-Year Network Development Plan[1)] (TYNDP) in compliance with Regulation (EC) n. 714/2009. It also assesses the adequacy between generation and demand in the ENTSO-E interconnected power system on mid- and long-term time horizons.

This SO&AF 2013 report is issued between the 2012 and 2014 TYNDP packages, updating the mid-term results from TYNDP 2012. It sets out three Scenarios for generation and demand[2)]: the Scenario EU 2020 is derived from the National Renewable Action Plans[3)] (NREAP) in compliance with the European 3 × 20 objectives; Scenario B ("Best Estimate") is based on the expectations of TSOs, while Scenario A ("Conservative") is derived from Scenario B, taking into account only the generating capacity developments which are considered secure.

As a new element, SO&AF 2013 contains quantitative data on two Visions[4)] for 2030, providing a bridge between the EU energy targets in 2020 and 2050. Visions 1 ("Slow progress") and 3 ("Green transition") are based on distinctively different assumptions, namely the actual future evolution of parameters expected to lie in-between. This conceptual difference to the 2020 Scenarios is also reflected in the method of data presentation used. Both visions assume a relatively low level of integration of the European energy market, and thus are based on national data, with Vision 1 assuming a general delay in progression towards 2050 energy roadmap goals, while Vision 3 is constructed to be "on track" towards these policy goals. The results of Visions 2 and 4, based on a well-functioning and strongly integrated market being constructed at a European level, are foreseen to be included in the TYNDP 2014 package.

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1) https://www.entsoe.eu/system-development/tyndp/tyndp-2012/

2) More about Scenarios in Chapter 2

3) NREAPs cover renewable energy and pumped storage plants only. The development of other generation plants is estimated by TSOs.

4) Details on 2030 Visions in Chapter 7

# Main Results – Load and Generation

**Load** in Scenario Best Estimate (B) increases continuously in both reference points - January and July (Figure 1.1a and b). Scenario A used in this report shows the firm generating capacity to be built and known to TSOs, and in this respect it could be understood as a "pessimistic" variant of Scenario B, aiming at identifying the investment needed in the period to maintain the level of adequacy. It is recommended that the load and decommissioning for both Scenarios be assessed using the same initial criteria.

Between 2013 and 2020, GB is the only country expecting a minor decrease (-0.06 %), while the highest annual increase is expected in Cyprus (+7.28 %), followed by Slovenia (+3.98 %). Average rate of growth is approximately 1 %, which is steady at the January reference point, and accelerating to close to 1.5 % at the July reference point towards the second half of the decade.

Scenario B has been revised compared to SO&AF 2012 – 2025, foreseeing lower initial load values and roughly similar growth rate, mainly as a result of the prolonged effects of economic crisis. Scenario EU 2020 forecasts a slower growth of load, resulting in an approximate 3 % lower value in 2020, compared to Scenario B, mainly due to the implemented energy efficiency measures.

Load growth continues at about the same rate between 2020 and 2030 under the assumptions in Vision 3, while Vision 1 foresees very similar load values in 2030 to those in 2020.

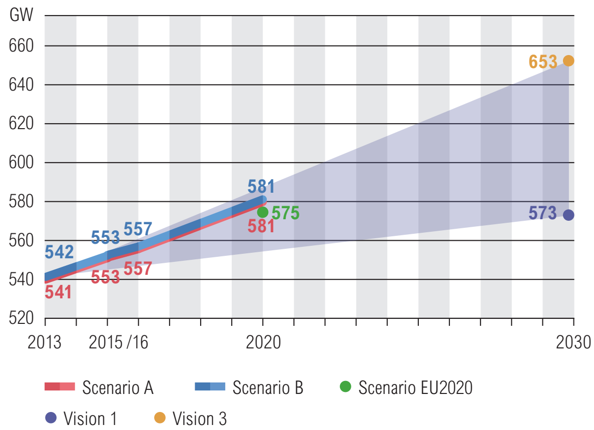


Figure 1.1a:
Load (all Scenarios, January)

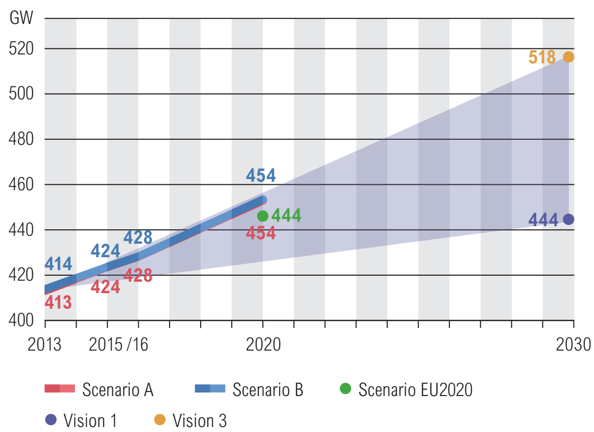


Figure 1.1b:
Load (all Scenarios, July)

With regards to Net Generating Capacity (NGC), the most rapidly developing energy sources are renewables. In Scenario B, their built-in capacity increases by 50 % in only 7 years (342 GW in 2013 and 512 GW in 2020). Most other main categories of generation capacity also increase during the assessed period, although at a lower rate. Nuclear built-in capacity is expected to stagnate until 2020. The main difference in Scenario EU 2020 can be observed in a higher Renewable Energy Sources (RES) capacity, compensated by lower amounts for fossil fuels. In other categories, Scenario EU 2020 results on a European level are similar to those of Scenario B; however, differences in individual countries may occur.

Norway (96 %) and Switzerland (73 %) are the countries with the highest share of RES in NGC, followed by Montenegro and Sweden, all dominated by hydro power plants. On the other hand, Denmark, Latvia and Portugal also display high values, with a different generation structure. Such strong RES development is mainly influenced by the legislation within each country (as well as the outstanding potential of course), which encourages the development of RES power plants (excluding or including hydro power plants) through the implementation of policies such as feed-in tariffs and/or the implementation of regulatory provisions put forward in the EU RES directive from 2009 on conditions for RES generators for access and connection to the grid. Subcategories of renewable generation are discussed in detail in the report, with wind and RES-hydro being the dominant ones in general.

The NGC of the fossil fuels category in Scenario B is expected to remain constant until 2015, decreasing by about 1% in 2016 as a consequence of the Large Combustion Plants Directive[5)] (LCP) and then starting to increase again up to 471 GW in 2020. However, on a longer horizon until 2030, a slow decrease of installed fossil-fired capacity is foreseen, amounting to 2–8% of current capacity, depending on the vision taken into account. Gas-fired power plants have the largest share within the fossil fuels category (being the only subtype to increase capacity in absolute value). This ratio increases from 40% in 2013 to 46% in 2020 and 53 to 58% in 2030. Other fossil fuel categories show either more or less visible decreases, or remain fairly stable.

It needs to be noted though that it is not within the scope of SO&AF methodology to fully take into account market trends, in particular the long-term economic viability of fossil-fuel plants. Work on extending the SO&AF methodology in this sense is foreseen for the coming reports.

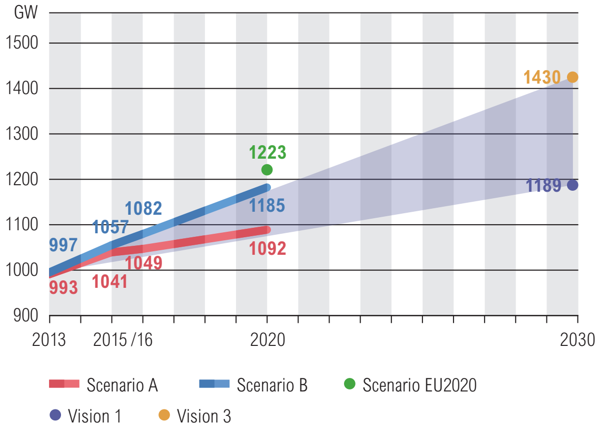


Figure 1.2:
ENTSO-E total NGC development (all Scenarios; January 7 p.m.)

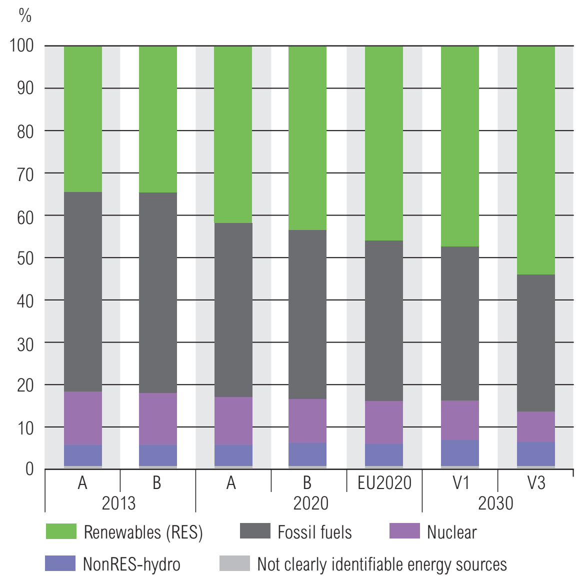


Figure 1.3:
ENTSO-E total NGC breakdown per fuel type (all Scenarios; January 7 p.m.)

Considering the only firm capacity projects in Scenario A, the total NGC is still increasing. Again, the largest share corresponds to fossil fuels and RES, but the share of RES is increasing (from 34% in 2013 to 42% in 2020), whereas the share of fossil fuels is decreasing (from 47% in 2013 to 41% in 2020). Among the fossil fuels, the gas power plants maintain the highest and slightly increasing share, whilst the remaining categories are either decreas-

5) Directive 2001/080/EC of the European parliament and of the Council of 23 October 2001 on the limitation of emissions of certain pollutants into the air from large combustion plants

ing or stable. In particular, the share belonging to coal power plants (hard coal and lignite) is expected to decrease from 39 % (2013) to 35 % (2020), and between 25 % and 30 % by 2030.

Within the total **renewable** capacity mix, wind, solar and biomass power plants are expected to increase, while the share of renewable hydro power plants is expected to decrease in some of the monitored years as a consequence of a lower development pace. Onshore wind farms play a major role in the wind power plants category; their share in total wind capacity reaching at least 80 % in all Scenarios until 2020. However, offshore wind generation is foreseen to become increasingly significant in the future. While in Vision 1, offshore remains at approximately 20 % of total wind installed capacity, in Vision 3 this ratio develops up to 28 %.

Furthermore, an important increase of solar capacity is expected for the future in consideration of the current policies adopted at EU and national level in the renewable and energy efficiency field.

# Main Results – System Adequacy

**Reliable Available Capacity** (RAC = NGC - UC, where UC means unavailable capacity and consists of non-usable capacity, outages, overhauls and reserves). In the best estimate, Scenario B increases at both reference points over the assessed period, continuously in the January reference point, and with a temporary halt between 2015 and 2016 at the July reference point. The RAC in January is higher than in July, as is required to cover load.

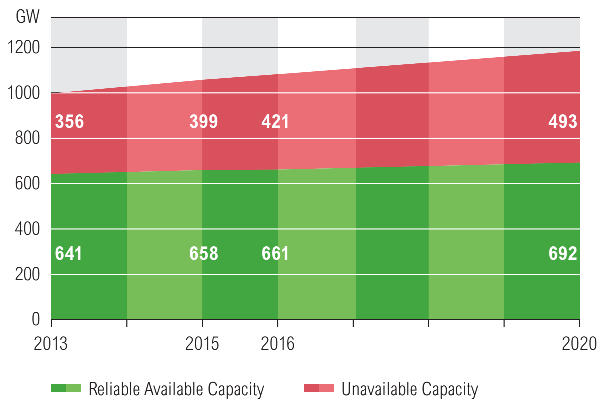


Figure 1.4:
ENTSO-E UC and RAC forecast (Scenario B, January reference point)

The **Remaining Capacity** (RC = RAC - load) increases continuously over the period between 2013 and 2020, once again with the exception of between 2015 and 2016. Remaining Capacity is higher than the Adequacy Reference Margin (ARM) during the entire period until 2020 at both reference points, and generation adequacy is thus met in most of the situations at an ENTSO-E system level (not considering capacity limitations between countries and/or regions). The level of adequacy (characterised by the difference between the RC and the ARM) is higher (by approximately 1 %) in 2020 than in 2013, at both reference points.

The average share of RAC in the total ENTSO-E NGC in 2020 is expected to be about 58 % in January (55 % in July). The available capacity is expected to grow at a slower pace than the generation capacity, due to an increased share of intermittent energy sources in the generation mix. Unavailable capacity thus occupies an increasingly larger share of NGC (Scenario EU 2020 results yield a RAC share of only 57 and 54 %, respectively). Furthermore, due to the high expected penetration of variable generation into the energy mix, complementary measures such as those described in the ENTSO-E network codes become even more urgently needed to ensure the balancing of the system in the most efficient manner for the consumer.

In Scenario A, RAC increases from 640 GW by 13 GW between 2013 and 2015; following this, it decreases back to 646 GW in 2016 and 645 GW in 2020 (for January 7 p.m.). Generation adequacy is expected to be met until 2016, while in 2020, the level of adequacy is becoming slightly negative. Additional generation units seem to be necessary in Europe to ensure a sufficient level of margins. In 2020, 38 GW of additional RAC is required to reach today's level of adequacy. Depending on the penetration of variable generation to the overall energy mix, this could imply that the level of required investment in terms of installed capacity is significantly higher. This situation is illustrated in Paragraph 4.1.

The adequacy levels seem sufficient, even when considering the shutdown of the nuclear power plants in Germany following the Fukushima accident in 2011, the nuclear phase out, as foreseen by Belgium law[6], and the additional nuclear phase out plans adopted in Switzerland. However, in the future reports it is planned to provide a deeper analysis of market trends, including information aiming at assessing the viability of current amount of fossil fuel plants or the outcomes of the on-going discussions on capacity mechanisms.

When comparing these results to the previous Scenario Outlook and Adequacy Forecast (published in 2012), no deterioration of the situation is observed.

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6) A revision of this law is currently under discussion in Belgium. This would result in the postponement by 10 years of the nuclear phase out of one unit. This adaptation was taken into account because the realisation is judged as very probable.

# 2 INTRODUCTION

# Objectives and Background

The ENTSO-E Scenario Outlook & Adequacy Forecast (SO&AF) assesses the mid- and long-term time horizon. Its focus is on adequacy analyses of the ENTSO-E interconnected transmission system throughout an overview of generation adequacy.

The SO&AF 2013 report provides a description of the Scenarios which are used as background assumptions for carrying out market and network studies within the TYNDP framework, also covering the economic view in the future.

The underlying Scenarios adopted for the TYNDP and used for the RgIPs are updated in order to capture the main evolution in respect to the Scenarios presented in the previous SO&AF 2012.

Apart from the above-mentioned, the SO&AF 2013 report aims to:

- assess the generation adequacy of the countries served by ENTSO-E's TSO members for the period 2013 – 2030. This will be done by providing an overview of the generation adequacy analysis for ENTSO-E as a whole, as well as through a revised regional assessment in order to pursue the regional cooperation set forth in Art. 12 of EC Regulation n. 714/2009;
- describe the generation adequacy assessment for each individual country, based on national data and comments received from member TSOs.

The above aims are served by two main chapters of the report:

- quantitative data on three Scenarios covering the period until 2020, whilst two bottom-up constructed Visions for 2030 are also presented. The visions of ENTSO-E in 2030 ("2030 Visions") aim to form a "bridge" between the European energy targets for 2020 and 2050, (such as, for instance, to verify whether the pathway realised for the future falls with a high level of certainty in the range described by the "2030 Visions"), and have been finalised after an extensive consultation process of the TYNDP 2014 methodology;
- the detailed adequacy analysis is carried out over three contrasting Scenarios for 2020, covering different evolutions for generating capacity and load, using the same criteria for the assessment. It is based on the comparison between the reliably available generation and load at two given reference points during the year (the third Wednesday in January at 7 p.m. and the third Wednesday in July at 11 a.m.) over the monitored time period under standard conditions.

The three mentioned Scenarios in brief are the following[7]:

– Scenario A (or Conservative Scenario) – this bottom-up scenario shows the necessary additional investments in generation to be confirmed in the future to maintain security of supply, if it is not maintained; it takes into account the commissioning of new power plants considered as sure; load forecast in this scenario is the best national estimate available to the TSOs, under normal climatic conditions.

– Scenario B (or Best Estimate Scenario) – this bottom-up scenario gives an estimation of potential future developments, provided that market signals give adequate incentives for investments; it takes into account the generation capacity evolution described in Scenario A, as well as future power plants, whose commissioning can be considered as reasonably credible according to the information available to the TSOs, while load should be treated the same as in Scenario A.

– Scenario EU 2020 – this top-down scenario provides an estimation of potential future developments, provided that governmental targets set for renewable generating capacities in 2020 are met; it derives from the EU policies on climate change and is based on national targets set in the National Renewable Energy Action Plan[8] (thereinafter only "NREAP") or equivalent governmental plans for renewable energy development if no NREAP applies; it does not impose any limitation with regard to further possible renewable energy generation development.

Although the assessment of these Scenarios is based on different approaches (top-down vs. bottom-up), the same criteria and methodology (see the reference to the SO&AF methodology) are used. The only difference however, is in the methodology for data provision. Scenarios A & B are based on the information and own estimations from respective TSOs, whereas Scenario EU 2020 is based on the NREAP or other official governmental plans.

Scenarios are also not intended to recommend any direction of grid development, as this is the purpose of the TYNDP, published biannually. However, there is a strong interplay between the chosen scenario and the results in the TYNDP in terms of grid development. A more in-depth description of the Scenarios and the methodology used for the adequacy assessment can be found in the separate methodology document (see reference to the SO&AF methodology).

In the current SO&AF 2013, the generation adequacy is assessed through the separate parameters Reliable Available Capacity (RAC), Remaining

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7) More information on methodology can be found in the Annex of this report.

8) According to article 4 of the Directive 2009/28/EC, member states are supposed to submit national renewable energy action plans by 30 June 2010. These plans have to provide detailed roadmaps of how each member state expects to reach its legally binding 2020 target for the share of renewable energy in their final energy consumption.

Capacity (RC) and Adequacy Reference Margin (ARM)[9]. The above-mentioned approach is a power balance-based assessment, and is intended to be integrated by the development of an energy approach assessment in the future, using the market analyses in the SO&AF report. It is also not the goal of SO&AF to assess the role of interconnectors and the impacts of generation adequacy on the grid. These issues are relevant for the TYNDP and RgIPs, rather than for SO&AF.

Wind (non-)availability is estimated upon the experience of each respective TSO. Other RES penetration and availability is also based on the data provided by respective data correspondents, and their experience. No common methodology is used for this purpose in the SO&AF report. The same also applies for the other energy sources assessed in the SO&AF report.

## Purpose of this Document

This document aims to describe the data and the methodology for system adequacy analysis used by ENTSO-E in its Scenario Outlook & Adequacy Forecast report (SO&AF).

The SO&AF aims to provide stakeholders in the European electricity market with an overview of generation, demand and their adequacy in different Scenarios for the future ENTSO-E Power System. The primary focus is on the power balance, margins, energy indicators and the generation mix; all of which are based on national data as they are being reported by each ENTSO-E member TSO, or a national organisation responsible for data collection for different TSOs.

The SO&AF is not concerned with the economic feasibility of generation assets per investigated scenario. The economic aspects are further investigated and analysed within the market studies performed in the framework of the ENTSO-E Ten-Year Network Development Plan (TYNDP). This framework is issued biannually, each even year. In market analyses, the fuel prices of different technologies can also be mirrored, as well as the greenhouse gas prices for example. The SO&AF is thus concerned with the technical aspects of the adequacy assessment without considering the economic aspects.

It is also not the goal of the SO&AF report to assess and report on the role of interconnectors and impacts on grid development, which is more relevant to Regional Investment Plans (RgIPs) and/or to the TYNDP.

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[9] For more information, refer to the methodology document.

# 3 SCENARIO OUTLOOK

# 3.1 Load Forecast

## Review of all Scenarios

Based on bottom-up Scenario (A and B) estimates, ENTSO-E load at reference point in January, as shown in Figure 3.1.1, is expected to increase by 40 GW between 2013 and 2020, reaching 581 GW. This corresponds to a compound annual growth of 1.02 %. The same increase is seen when referring to July, going from 414 GW in 2013 up to 454 GW in 2020.

Load estimate of the top-down Scenario EU 2020 is slightly lower, with 575 GW in January and 444 GW in July.

Both long run Vision 1 and Vision 3 estimates result in load increase between 2013 and 2030. It is assumed that Vision 1 means not exceeding the level of load forecast in 2020 for Scenario EU 2020. On the other hand, in Vision 3, load is to increase up to 653 GW in January (14 % increase compared to EU 2020) and up to 518 GW (17 % increase) in July.

As shown in Figure 3.1.3, the rate of load growth of the updated Scenario B in January does not differ dramatically from the previous SO&AF 2012 – 2030. However, new load value for January 2020 is lower due to a lower starting point in 2013. In spite of TSO's expectations, a revision of the top-down Scenario EU 2020 resulted in load increase compared to values in the previous report.

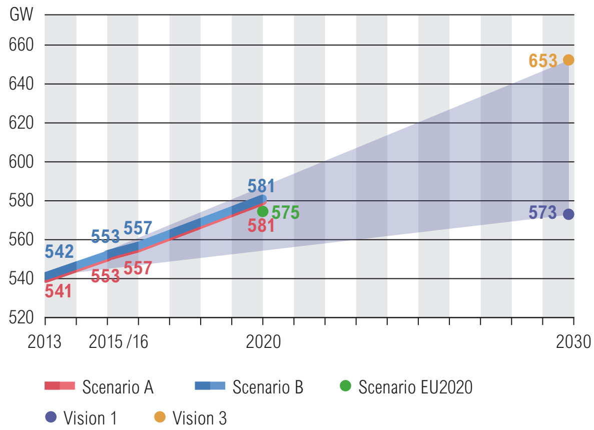



Figure 3.1.1:
ENTSO-E load forecast for all Scenarios in January

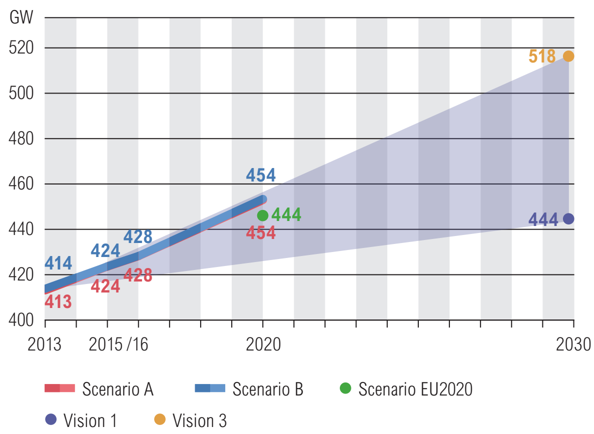



Figure 3.1.2:
ENTSO-E load forecast for all Scenarios in July

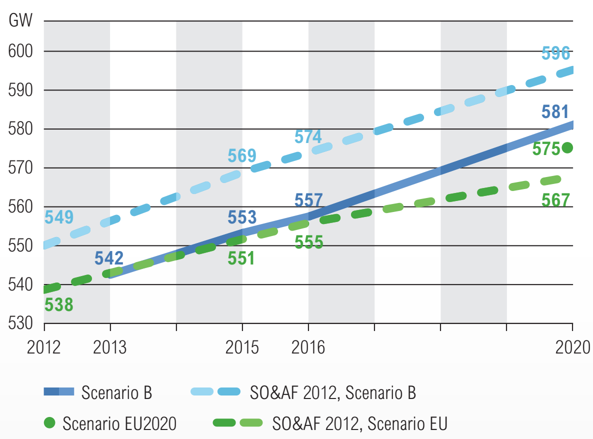



Figure 3.1.3:
Comparison of ENTSO-E load forecast in SO&AF 2012 – 2030 and in SO&AF 2013 – 2030 for Scenario B and EU 2020 in January

## Scenarios A, B

ENTSO-E load trends of Scenario B are presented in Table 3.1.1. In January, annual growth rate is expected to increase from 0.94 % in the next 4 years to 1.07 % between 2016 and 2020. The same applies to July when an annual growth rate of 1.15 % is to evolve to 1.43 % between 2016 and 2020.

| | 2013–2016 | | 2016–2020 | | 2013–2020 | |
|---|---|---|---|---|---|---|
| | [%, annual] | [GW, total] | [%, annual] | [GW, total] | [%, annual] | [GW, total] |
| January 7 p.m. | 0.94 % | 15.36 | 1.07 % | 24.22 | 1.01 % | 39.58 |
| July 11 a.m. | 1.15 % | 14.45 | 1.43 % | 25.12 | 1.31 % | 39.57 |

Table 3.1.1:
ENTSO-E load increase for Scenario B

Looking at the load growth of individual countries, expected in January, between 2013 and 2020, GB is the only one showing a minor decrease (-0.06 %). The highest annual increase is expected in Cyprus (+7.28 %), followed by Slovenia (+3.98 %), Romania (+2.84 %), Bosnia (+2.69 %), Luxemburg (+2.68 %), Hungary (+2.40 %), Spain (+2.36 %), Greece[10] (+2.31 %) and Croatia (2.23 %).

The revision of Scenario B has led to decreasing load estimates by 2.42 % in January 2020, when compared to previous SO&AF. A higher decrease (-5.75 %) is expected in July.

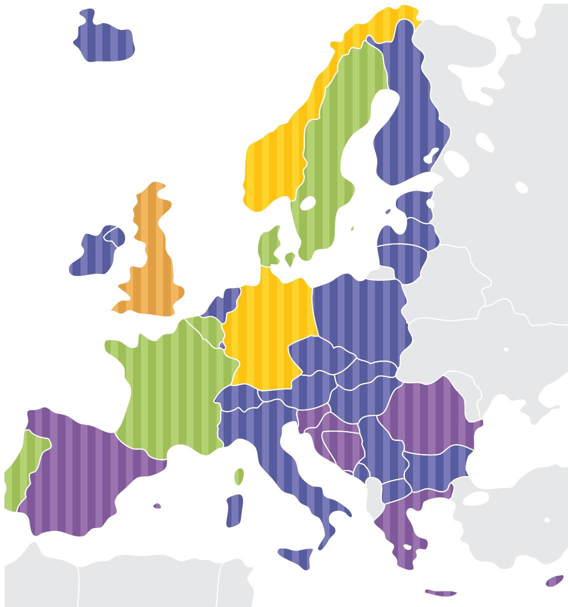



Figure 3.1.4:
ENTSO-E average annual load growth per country between 2013 and 2020, Scenario B, January

| | Scenario B to previous SO&AF Scenario B | |
|---|---|---|
| | [%, annual] | [GW, total] |
| January 7 p.m. | -2,42% | -14,41 |
| July 11 a.m. | -5,75% | -27,65 |

Table 3.1.2:
Differences of ENTSO-E load in Scenario B, compared to Scenario B of SO&AF 2012–2030, year 2020

## Scenario EU 2020

The load forecast for Scenario EU 2020 is established on the basis of the "Additional energy efficiency scenario" of the NREAPs. It takes into account national plans for a complete mix of energy consumed in the national economy in order to meet national target value. This is in accordance with the goals of renewable energy source utilisation in total energy consumption, as defined in the third energy legislation package of the European Union.

NREAPs, however, are not available for each ENTSO-E country, since not every ENTSO-E country is an EU member. Furthermore, the first edition of the NREAPs was established before the financial and economic crisis, meaning that not all EU countries provided an update. For ENTSO-E countries not belonging to the EU and

10) The load growth of Greece between 2013 and 2020 is influenced by the fact that the load of the Cyclades Islands and the Island of Crete is added to the consumption of the grid in the mainland, based on the assumption that the interconnection of said islands is expected to be commissioned by the years 2017 and 2019, respectively.

| | Scenario EU 2020 to Scenario B | | Scenario EU 2020 to Scenario EU 2020 in SO&AF 2012–2030 | |
|---|---|---|---|---|
| | [%] | [GW] | [%] | [GW] |
| January 7 p.m. | -1.09% | -6.33 | 1.29% | 7.34 |
| July 11 a.m. | -2.02% | -9.16 | -4.54% | -21.13 |

Table 3.1.3:
Differences of ENTSO-E load in Scenario EU 2020 with relation to Scenario B and Scenario EU 2020 of SO&AF 2012–2030

without an NREAP, the latest official document describing the long-term vision of the country or the TSO's best estimate was used.

As seen in Table 3.1.3, when compared to the previous SO&AF, the forecast ENTSO-E load of the new Scenario EU 2020 is higher in January (+1.29%) and lower in July (-4.54%). Nevertheless, the differences between Scenario EU 2020 and Scenario B are both negative: -1.09% in January and -2.02% in July. The reasons behind these divergences are most likely linked to distinct approaches; while Scenario EU 2020 tends to reflect the political targets of each respective national government, Scenario B is the best estimation of each TSO, reflecting more the view and expectations of TSOs.

Differences in load (at reference point January 7 p.m.) between Scenario EU 2020 and Scenario B are shown in Figure 3.1.5. Luxemburg presents the lowest EU 2020 load compared to Scenario B (-26.15%), followed by Slovenia (-13.73%) and Italy (-9.98%). At the other end we find Slovakia (+6.94%), Hungary (+6.45%) and Montenegro (+6.25%).

Concerning the revision of Scenario EU 2020 (Figure 3.1.6), the majority of countries increase their EU 2020 load target in January. These revisions may be due to the consideration of recent trends of dynamics, such as the use of electricity affecting peak demand, or the evolution of national targets. Indeed, they do not necessarily imply the same trend for annual energy consumption.

This increase can especially be observed in Romania (+12.07%), Poland (+10.75%), France (+9.16%), Finland (+7.01%), Hungary (+6.45%) and Norway (+5.77%). However, certain reduc-

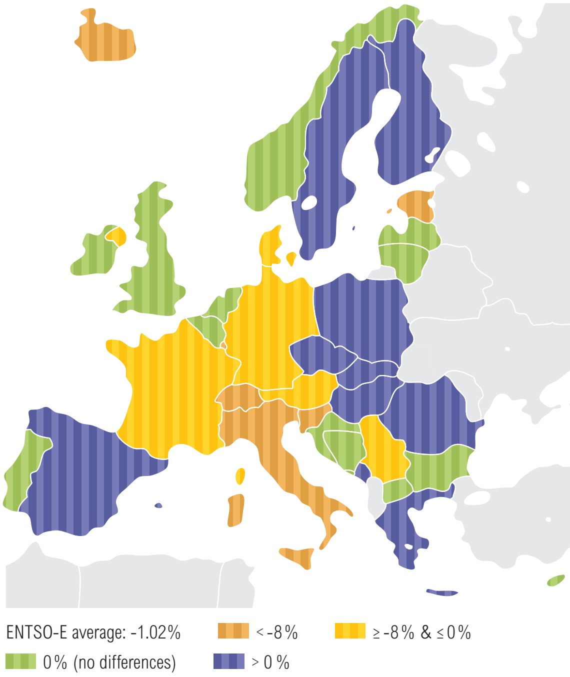




Figure 3.1.5:
Difference of ENTSO-E load in 2020 in Scenario EU 2020 with relation to Scenario B, January

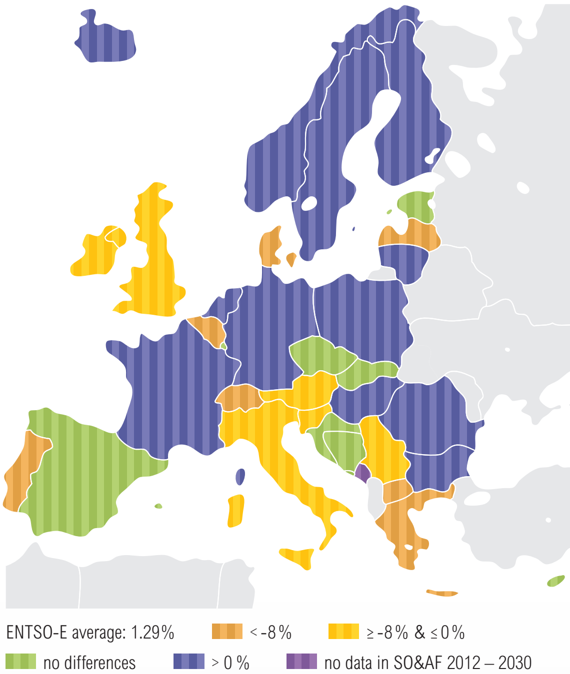




Figure 3.1.6:
Difference of ENTSO-E load in 2020 in Scenario EU 2020 with relation to Scenario EU 2020 of SO&AF 2012–2030, January

tions have also been reported. The highest decreases are presented by Portugal (-16.40 %), the FYROM (-13.68 %), Belgium (-10.81 %), Denmark (-10.29 %), Greece (-8.42 %), Switzerland (-8.18 %), and Latvia (-8.13 %).

## Scenario Vision 1 and Vision 3

The slow progress of the Vision 1 load is evidenced by annual growth rates ranging from around 0.33 % to 0.42 % between 2013 and 2030, as shown in Table 3.1.4. The more favourable the economic and financial conditions of Vision 3, the higher the load forecast for the same period, with annual growth rates between of 1.10 % and 1.33 % (in January and July).

| | Vision 1, 2013–2030 | | Vision 3, 2013–2030 | |
|---|---|---|---|---|
| | [%, annual] | [GW] | [%, annual] | [GW] |
| January 7 p.m. | 0.33 % | 31.40 | 1.10 % | 111.17 |
| July 11 a.m. | 0.42 % | 30.23 | 1.33 % | 104.05 |

Table 3.1.4:
ENTSO-E load increase for Vision 1 and Vision 3

Despite the economic and financial constraints of Vision 1, certain countries foresee even higher annual load growth for the period 2013–2030 than the ENTSO-E average forecast in Vision 3 (>1.10 %). This is the case among others in Cyprus (+3.79 %), Latvia (+2.03 %), Croatia (+1.85 %), Bosnia & Herzegovina (+1.64 %) and Spain (+1.54 %). Some other countries, however, indicate negative annual growth rates: Switzerland (-0.50 %), France (-0.13 %), Italy (-0.12 %), Great Britain (-0.10 %) and the Netherlands (-0.02 %).

Taking into account the favourable conditions of Vision 3, no country has reported negative annual growth for the period spanning 2013–2030. Countries expecting the highest annual growth rate include Cyprus (+3.79 %, the same annual growth as indicated for Vision 1), Greece (+2.83 %), Romania (+2.76 %), Lithuania (+2.55 %), Spain (+2.49 %), Latvia (2.35 %) and Slovenia (+2.33 %). On the contrary, below ENTSO-E average expectation, we find Great Britain (+0.24 %), France (+0.35 %), Norway (+0.49 %), Switzerland (+0.58 %), Sweden (+0.68 %) and Germany (+0.70 %), among others.

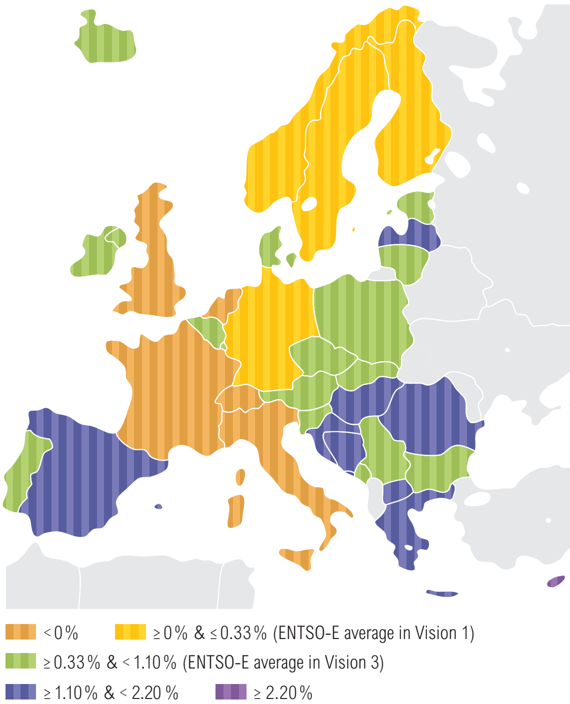
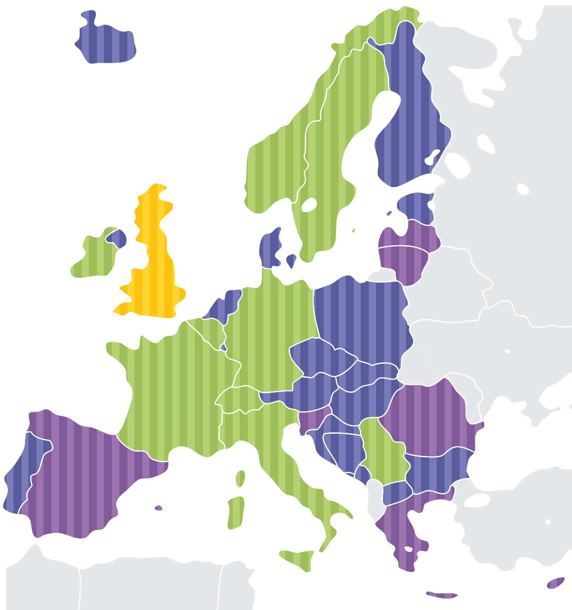


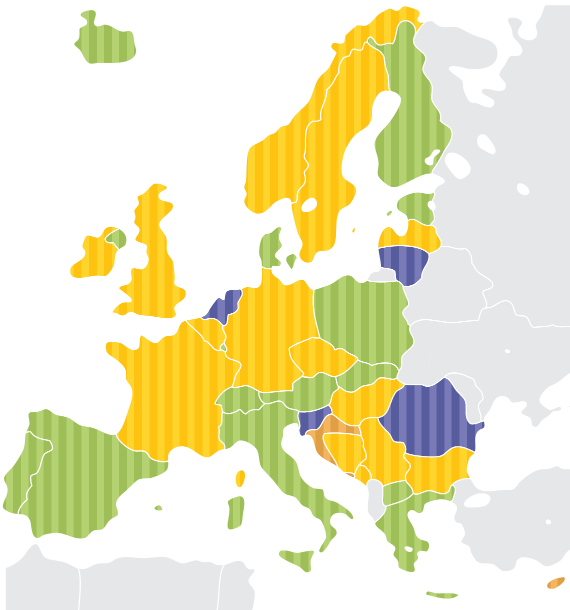

Figure 3.1.7:
Average annual load growth per country between 2013 and 2030, Scenario Vision 1, January

Compared to Vision 1, the contrasting trends assumed in Vision 3 lead to ENTSO-E load values which are 79.77 GW higher (+13.92 %) in January and 73.82 GW higher (+16.62 %) in July.



< 0 %   ≥ 0 % & ≤ 0.33 % (ENTSO-E average in Vision 1)
≥ 0.33 % & < 1.10 % (ENTSO-E average in Vision 3)
≥ 1.10 % & < 2.20 %   ≥ 2.20 %

Figure 3.1.8:
Average annual load growth per country between 2013 and 2030, Scenario Vision 3, January



no differences   > 0.0 % & < 13,92 % (ENTSO-E average)
≥ 13,92 % (ENTSO-E average) & < 27.84 %   ≥ 27.84 %

Figure 3.1.9:
Difference of ENTSO-E load in 2030 in Vision 3 with relation to scenario Vision 1, January

Among the countries which forecast the highest differences in (January) load between the two assessed 2030 visions are Lithuania (+38.34 %), Slovenia (+34.09 %), the Netherlands (+33.99 %) and Romania (+29.32 %). Cyprus and Croatia have not reported any differences.

| | Vision 3 to Vision 1 | |
|---|---|---|
| | [%] | [GW] |
| January 7 p.m. | 13.92 % | 79.77 |
| July 11 a.m. | 16.62 % | 73.82 |

Table 3.1.5:
Differences of ENTSO-E load in Vision 3 with relation to Vision 1

# 3.2 Net Generating Capacity (NGC)

## 3.2.1 Total NGC

This chapter contains the main description and assessment for each generation category across all Scenarios. More details are available within each subparagraph, where particular kinds of fuel and Scenarios are dealt with.

### Review of all Scenarios

The evolution of total NGC for the entire ENTSO-E is shown in Figure 3.2.1.1.

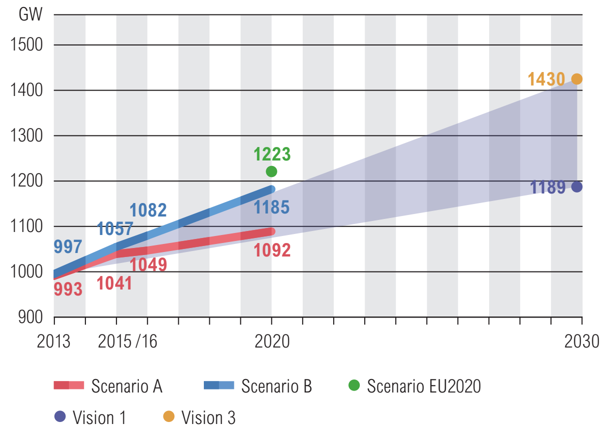



Figure 3.2.1.1:
ENTSO-E total NGC forecast; all Scenarios; January 7 p.m.

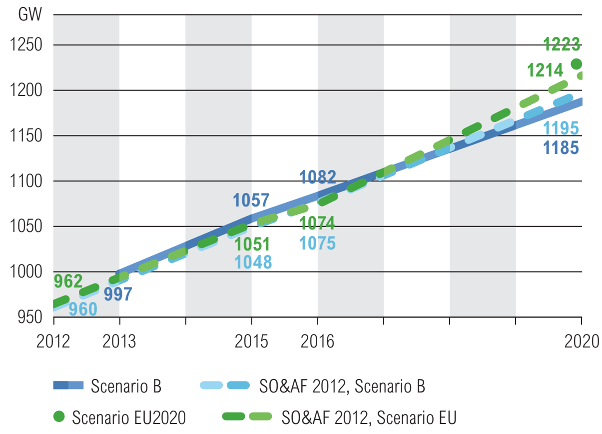



Figure 3.2.1.2:
Comparison of NGC between SO&AF 2012 and SO&AF 2013; Scenarios B and EU 2020; January 7 p.m.

In contrast with what happens to load forecast in year 2020, ENTSO-E total generation capacity in Scenario EU 2020 (1,223 GW) is higher than in Scenario B (1,185 GW). As expected, the Conservative Scenario A forecasts the lowest growth of the three Scenarios, reaching only 1,092 GW in 2020, since only confirmed generation projects are considered. The general guidelines for the national bottom-up Visions 2030 state that countries should fulfil their generation adequacy criteria under normal conditions. In general, Vision 1 is aligned with Scenario A, with a total capacity of 1,189 GW in 2030. This Vision has a January peak load which is lower than that collected for Scenario A in 2020. Compared to EU 2020, generation in Vision 1 is lower by 3 %, while there are similar peak loads for the third Wednesday of January. Vision 3 is close to being the extension of Scenario B trends, reaching 1,430 GW in 2030.

The differences between updated generation forecasts (in January) and the reported values in the previous SO&AF are shown in Figure 3.2.1.2. Generally speaking, deviations are quite small (less than 1 %). In 2020, new Scenario EU 2020 shows an increase of 9 GW, while Scenario B decreases by 10 GW.

The trend of installed generation mix generally shows a decreasing importance of fossil fuels over RES, as seen in Figure 3.2.1.3. During the period 2013 – 2020 this is evidenced by the bottom-up Scenarios, with the fossil fuels average decreasing to a share price of 7 pp and RES increasing to 8 pp. In 2020, installed RES share is 46 % in Scenario EU 2020. Ten years later, this value is expected to rise to 47 % in Vision 1 and up to 54 % in Vision 3. Decommissioning of nuclear power plants results in share reductions from around 12 % (in 2013) to 7 % in the case of Vision 1 and to 9 % in Vision 3, in 2030.

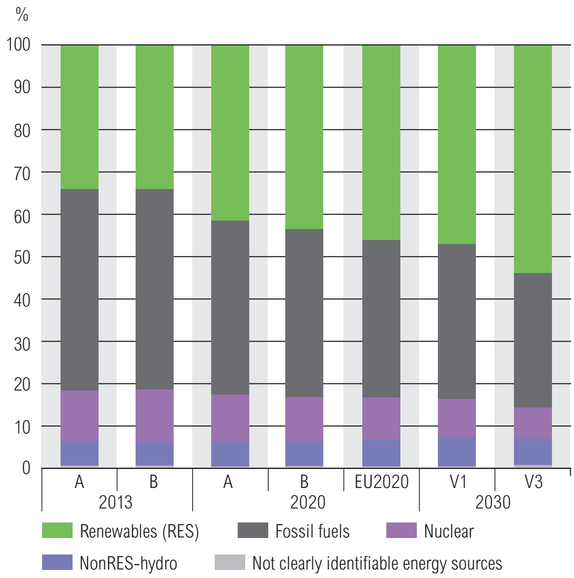



Figure 3.2.1.3 and 3.2.1.4:
ENTSO-E total NGC breakdown in 2013, 2020 and 2030; all Scenarios; January 7 p.m. (relative share and absolute values)

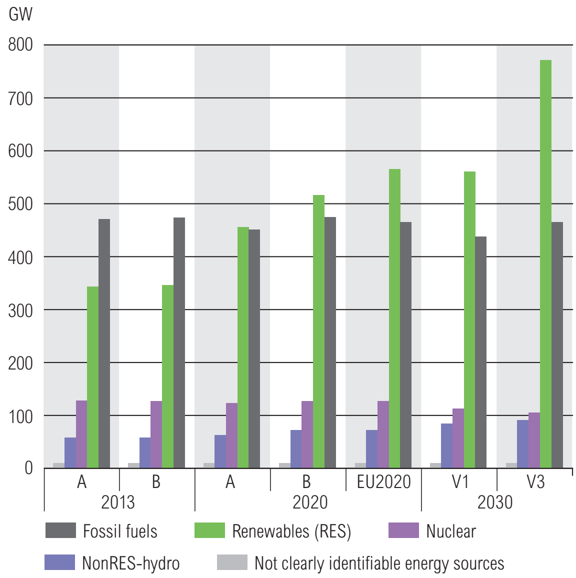



Figure 3.2.1.4

## Scenarios A, B

Variation of capacity in absolute values and average growth rates are respectively shown in Tables 3.2.1.1 and 3.2.1.2 for Scenarios A and B. The conservative forecast generally shows lower growth rates which decrease during the analysed period. TSO best estimates maintain average annual growth rates of around 2.5 %.

| | Scenario A | | | Scenario B | | |
|---|---|---|---|---|---|---|
| [GW, total] | **2013–2016** | **2016–2020** | **2013–2020** | **2013–2016** | **2016–2020** | **2013–2020** |
| January 7 p.m. | 56 | 43 | 99 | 85 | 103 | 188 |
| July 11 a.m. | 55 | 40 | 94 | 78 | 111 | 188 |

Table 3.2.1.1 :
ENTSO-E absolute evolution of total NGC for Scenarios A and B

| | Scenario A | | | Scenario B | | |
|---|---|---|---|---|---|---|
| [%, yearly] | **2013–2016** | **2016–2020** | **2013–2020** | **2013–2016** | **2016–2020** | **2013–2020** |
| January 7 p.m. | 1.86 % | 1.00 % | 1.36 % | 2.77 % | 2.31 % | 2.50 % |
| July 11 a.m. | 1.79 % | 0.92 % | 1.29 % | 2.51 % | 2.46 % | 2.48 % |

Table 3.2.1.2 :
ENTSO-E yearly evolution of total NGC for Scenarios A and B

Looking at subcategories in Table 3.2.1.3, the main variations occur in RES and non-RES hydro with the first increasing annually between 4 % and nearly 6 %, whilst the latter increases between 1.3 % and 3 %. With regards to nuclear power plants, the common trend is essentially to maintain capacity until 2020.

| | Scenario | 2013–2020 | fossil fuels | RES | Non-RES hydro | Nuclear |
|---|---|---|---|---|---|---|
| January 7 p.m. | A | [GW, total] | -21 | 114 | 6 | -1 |
| | | [%, yearly] | -0.64 % | 4.23 % | 1.44 % | -0.11 % |
| | B | [GW, total] | 3 | 170 | 13 | 2 |
| | | [%, yearly] | 0.10 % | 5.93 % | 3.03 % | 0.21 % |
| July 11 a.m. | A | [GW, total] | -18 | 110 | 5 | -3 |
| | | [%, yearly] | -0.57 % | 4.01 % | 1.34 % | -0.34 % |
| | B | [GW, total] | 7 | 168 | 13 | 1 |
| | | [%, yearly] | 0.21 % | 5.74 % | 2.94 % | 0.12 % |

Table 3.2.1.3 :
ENTSO-E NGC subcategories evolution for Scenarios A and B

The evolution of generation in Scenario B (in January) is shown in Figure 4.2.1.5, where only RES capacity presents noticeable variation in absolute terms, reaching 512 GW. Consequently, RES share in generation mix increases by around 8 percentage points. The slight increase of non-RES hydro capacity enables this subcategory to maintain its share (around 12 %).

Individual country generation mix in Scenario B (in January 2020) is depicted in Figure 3.2.1.6 (no correction regarding the size of the country) and Figure 3.2.1.7. Forecasts of aggregated RES capacity in Germany (122.7 GW), Italy (66.7 GW), Spain (54.4 GW) and France (47.9 GW) total approximately 290 GW, which is higher than the remaining ENTSO-E countries put together.

With regards to the RES share in NGC of Scenario B, Norway will maintain its leading position in 2020 with 96 %, followed by Switzerland (73 %), Montenegro (69 %), Latvia (68 %), Denmark, Sweden and Portugal (67 %). This beeing said, certain countries will however strongly rely on fossil fuel, such as Estonia (83 %), the Netherlands (80 %), Cyprus (78 %) and Poland (75 %). France will maintain around 63 GW of its nuclear power, representing the highest absolute value and share (47 %) among ENTSO-E countries.

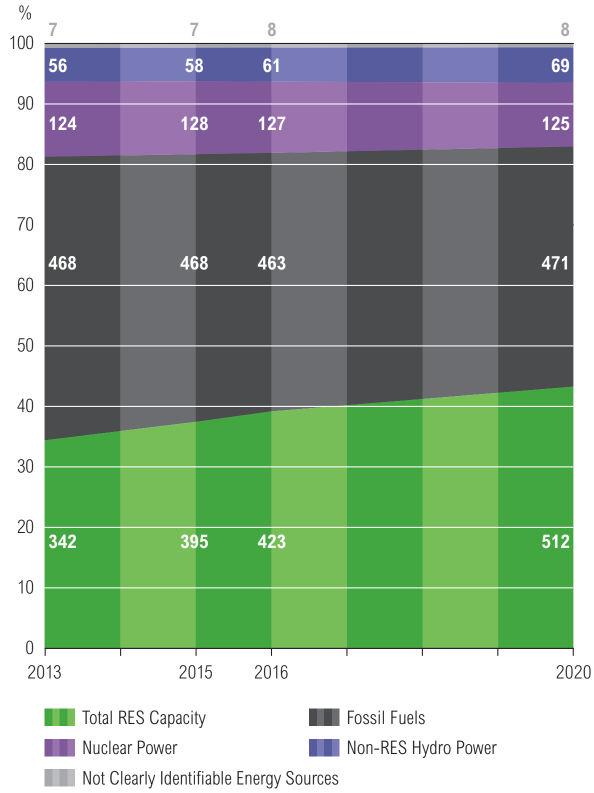



Figure 3.2.1.5:
ENTSO-E total NGC mix; Scenario B; January 7 p.m.

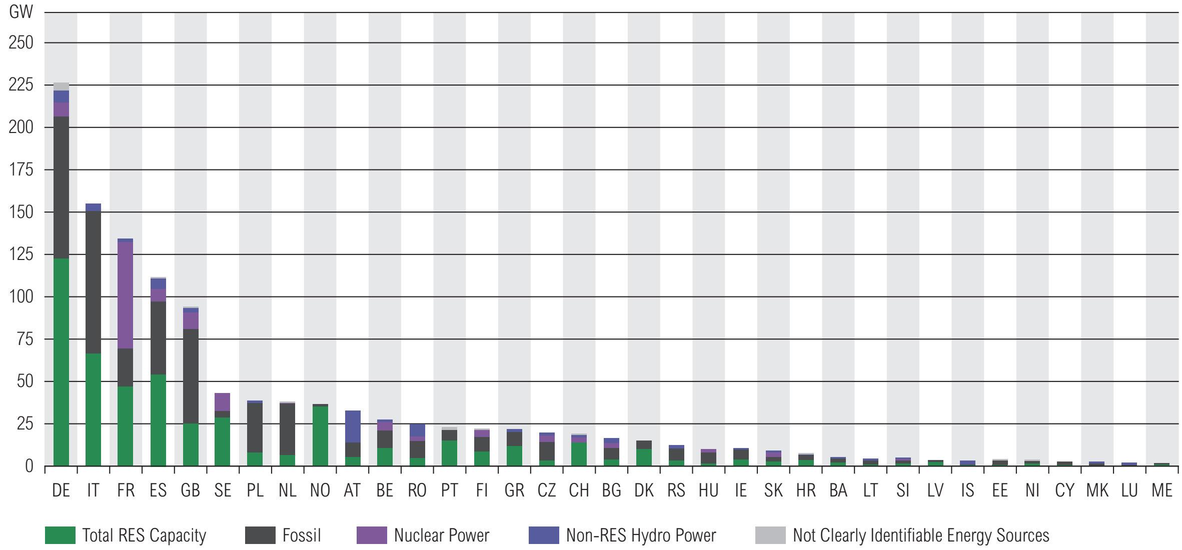



Figure 3.2.1.6:
Total NGC breakdown per country in 2020; Scenario B; January 7 p.m.

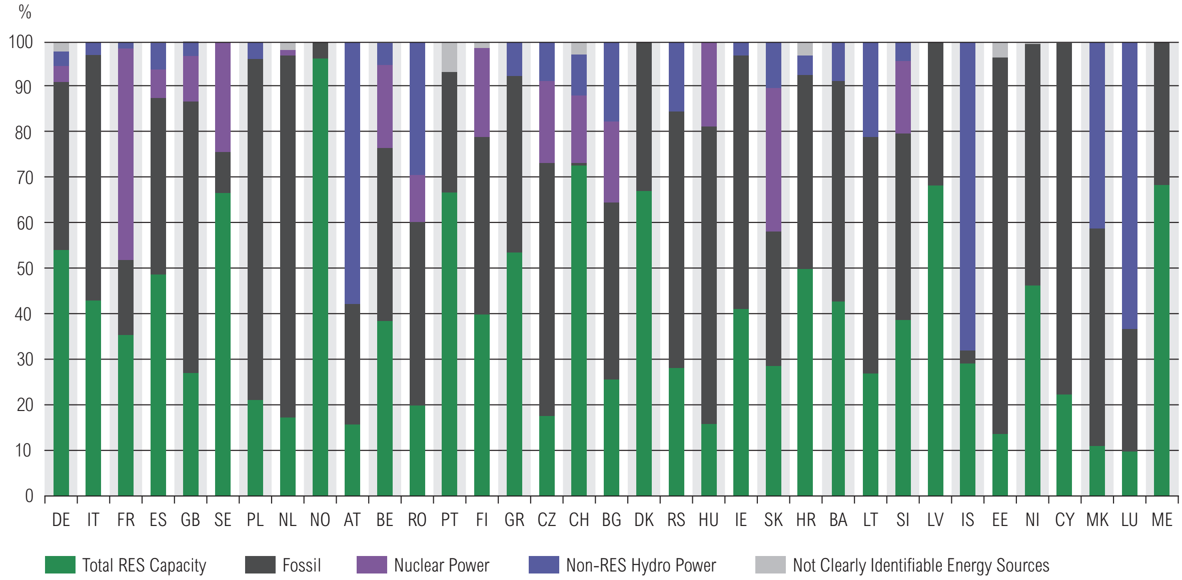



Figure 3.2.1.7:
Total generation capacity mix per country in 2020; Scenario B; January 7 p.m.

## Scenario EU 2020

The differences in NGC between Scenario EU 2020 and its previous version, as well as in comparison to Scenario B, are shown in Table 3.2.1.4 and Table 3.2.1.5. Revised Scenario EU 2020 presents a very small increase in NGC (<1 %) compared to the previous one published in SO&AF 2012. This difference is higher with relation to Scenario B (below +3.5 % however), as a result of

| | **Scenario EU 2020 to Scenario B** | | **Scenario EU 2020 to Scenario EU 2020 of SO&AF 2012–2030** | |
|---|---|---|---|---|
| | [%] | [GW] | [%] | [GW] |
| January 7 p.m. | 3.21 % | 38 | 0.78 % | 9 |
| July 11 a.m. | 3.36 % | 40 | 0.94 % | 12 |

Table 3.2.1.4:
Differences of ENTSO-E NGC in Scenario EU 2020 compared to Scenario B and Scenario EU 2020 of SO&AF 2012–2030

| | Scenario EU 2020 to Scenario B | fossil fuels | RES | Non-RES hydro | Nuclear |
|---|---|---|---|---|---|
| January 7 p.m. | [GW] | -10 | 48 | 2 | -1 |
| | [%] | -2.22 % | 9.30 % | 3.26 % | -1.13 % |
| July 11 a.m | [GW] | -12 | 53 | 3 | -3 |
| | [%] | -2.63 % | 10.18 % | 3.68 % | -2.15 % |

Table 3.2.1.5:
Differences of ENTSO-E NGC in Scenario EU 2020 compared to Scenario B

increased RES (+9.3 % to +10.2 %, depending on season) and non-RES hydro (+3.2 % to +3.7 %). This is also due to a decrease of both Nuclear (-1.1 % to -2.2 %) and fossil fuels (-2.2 % to -2.6 %).

Finland presents the highest difference of NGC (+13 %) when comparing Scenarios EU 2020 and B. On the other side, in 2020, Montenegro's top-down Scenario is forecasting the lowest generation capacity in comparison to Scenario B (-14 %). With regards to RES, 57 % of ENTSO-E countries foresee higher shares of this subcategory against Scenario B, led by Estonia (+109 %).

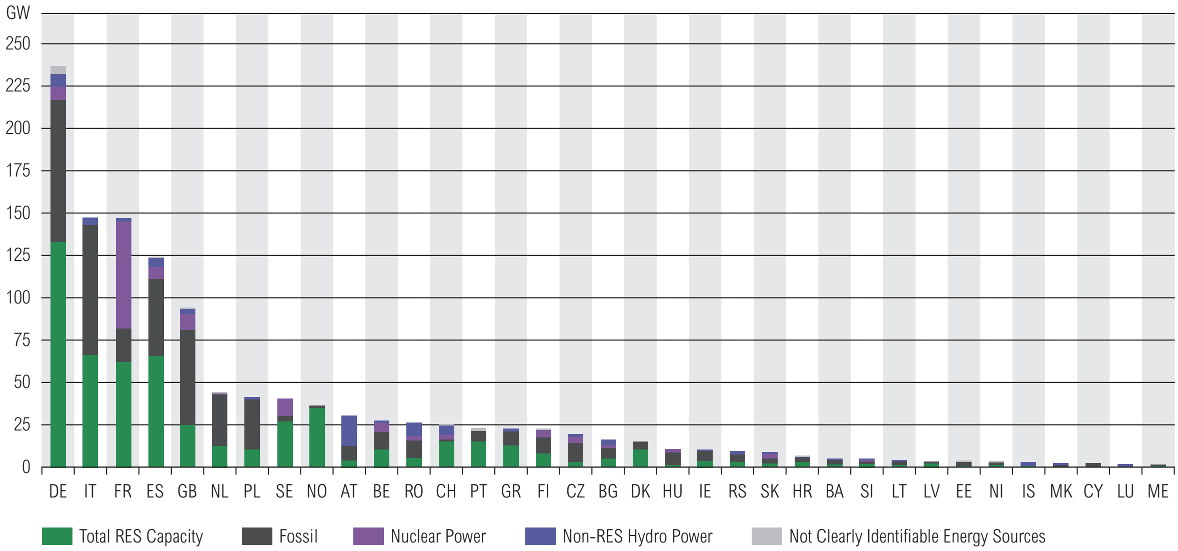



Figure 3.2.1.8:
Total NGC breakdown per country in 2020; Scenario EU 2020; January 7 p.m.

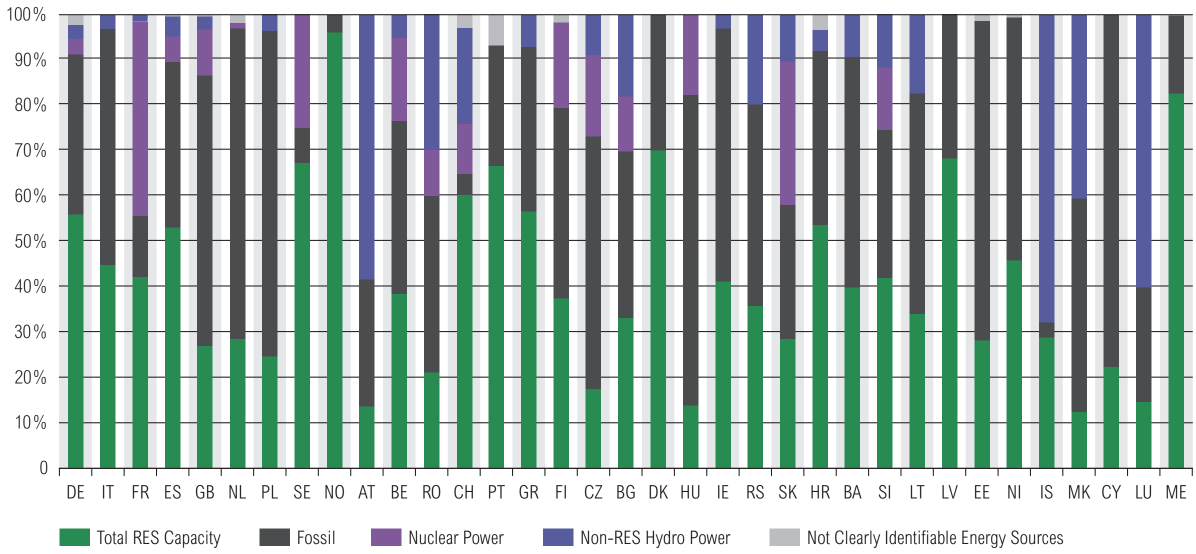



Figure 3.2.1.9:
Total generation capacity mix per country in 2020; Scenario EU 2020; January 7 p.m.

### Scenario Vision 1 and Vision 3

The evolution of NGC as forecast in long-term Visions is depicted in Table 3.2.1.6. Compared to Scenario B in 2013, the NGC in Vision 1 is to increase by 192 GW (in January), representing an average annual growth rate of approximately 1%. In the case of Vision 3, NGC increases almost 430 GW, meaning an annual growth of around 2.1%. Note that the average annual growth rate of the load is between 0.33% and 0.42% in Vision 1 while this figure is between 1.1% and 1.3% in Vision 3.

| | Vision 1, 2013–2030 | | Vision 3, 2013–2030 | |
|---|---|---|---|---|
| | [%, annual ] | [GW] | [%, annual ] | [GW] |
| January 7 p.m. | 1.04% | 192 | 2.14% | 433 |
| July 11 a.m. | 1.00% | 185 | 2.11% | 429 |

Table 3.2.1.6:
ENTSO-E NGC increase for Vision 1 and Vision 3 with relation to Scenario B 2013

Almost every country is to increase its share of RES in the long-term. In the case of Vision 1, exceptions to this rule include Montenegro (-10%) and Lithuania (-7%). In Vision 3, only Switzerland and Lithuania foresee a very slight decreasing ratio of RES.

## 3.2.2 Fossil Fuel Generation Capacity

### Review of all Scenarios

The NGC of the fossil fuel category is expected to be maintained until 2015 (maximum is 468 GW for January and 469 GW for July) and to fall in 2016 (to approximately 456 GW in Scenario A and 463 GW in Scenario B; see Figure 3.2.2.1). Between 2016 and 2020, fossil fuel generation capacity is expected to

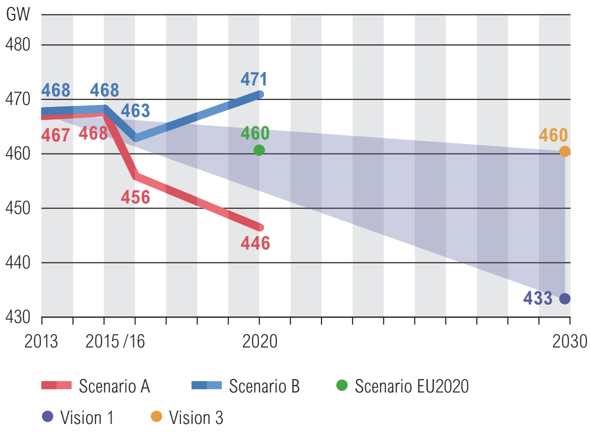



Figure 3.2.2.1:
ENTSO-E fossil fuels generation capacity forecast; all Scenarios; January 7 p.m.

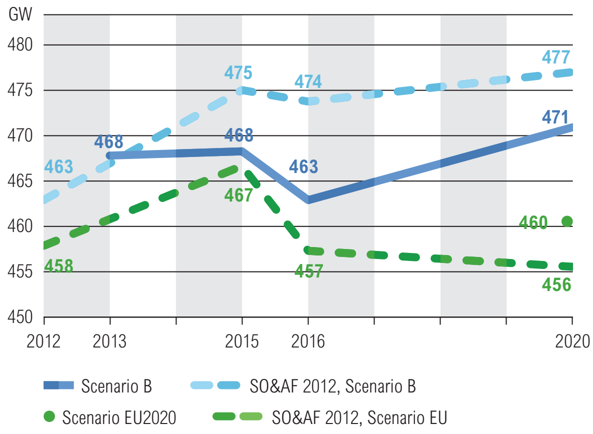



Figure 3.2.2.2:
Comparison of fossil fuels generation capacity between SO&AF 2012 and SO&AF 2013; Scenarios B and EU 2020; January 7 p.m.

decrease by 4.5 % in Scenario A (446 GW) and to slightly increase (+0.7 %) in Scenario B (471 GW). In the 2020 forecast, fossil fuel capacity in Scenario EU 2020 is between the two bottom-up Scenarios, amounting to 460 GW.

The general trend of long-term Visions is to reduce fossil fuels until 2030. In Vision 3, fossil fuel generation capacity totals 460 GW (approximately the same as in Scenario EU 2020 in 2020). In Vision 1, it further decreases to 433 GW. It makes sense that the installed capacity is lower in Vision 1 than in Vision 3 due to a lower load in the first Vision. The general guidelines for these Visions state that generation adequacy criteria should be met at national level under normal circumstances.

When compared to the previous SO&AF, fossil fuel capacity in Scenario B is lower (by less than 3 %). This is mostly because it is not increasing until 2015, as previously assumed. In 2020, this results in approximately 6 GW less. With regards to Scenario EU 2020, in 2020 this capacity is higher by 5 GW.

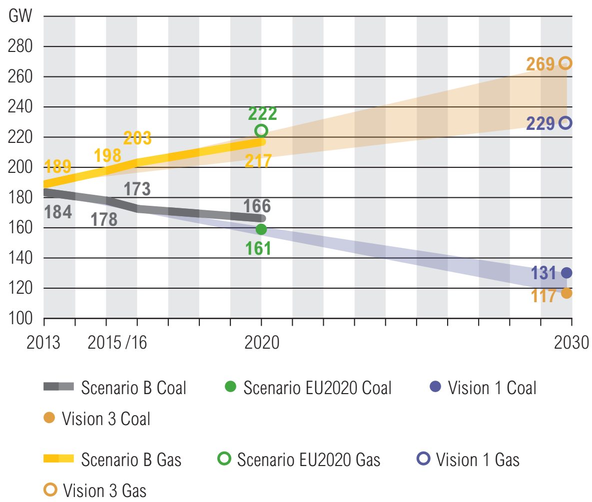



Figure 3.2.2.3:
ENTSO-E coal (hard coal + lignite) and gas generation capacity forecast; all Scenarios; January 7 p.m.

Along with the general decreasing trend of fossil fuels based capacity, a clear replacement trend of coal (as well as lignite, oil and other fuels) by natural gas is forecast, as seen in Figure 3.2.2.3 and Figure 3.2.2.4. This is particularly important in Vision 3, where the lowest limits of coal based installed capacity are combined with the highest capacity of gas fuelled power plants.

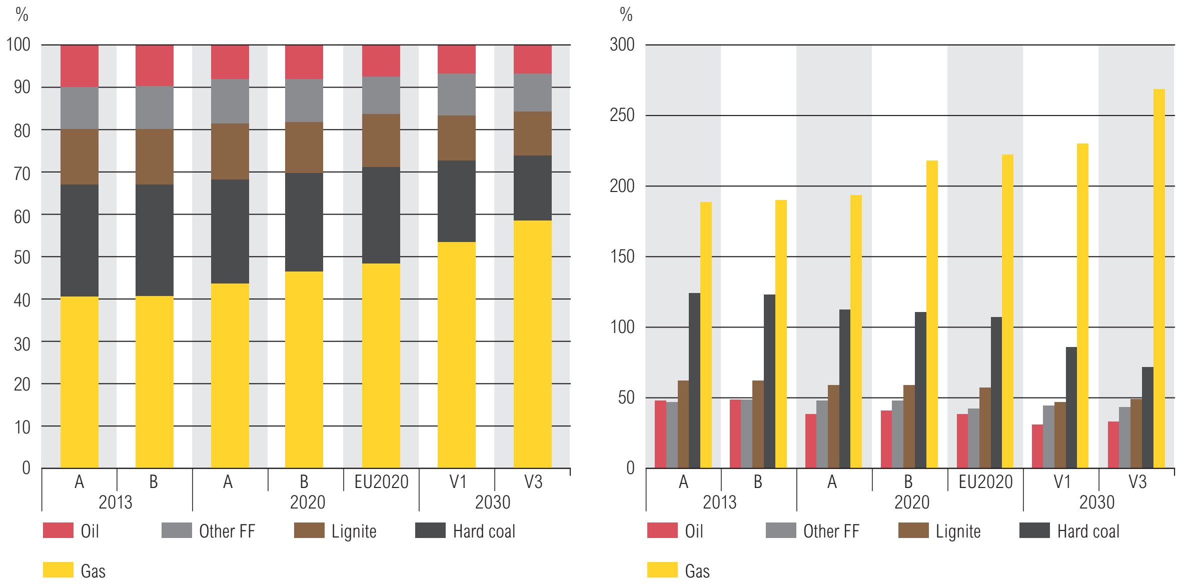



Figure 3.2.2.4:
ENTSO-E fossil fuels generation capacity breakdown in 2013, 2020 and 2030; all Scenarios; January 7 p.m.
(ratios and absolute values)

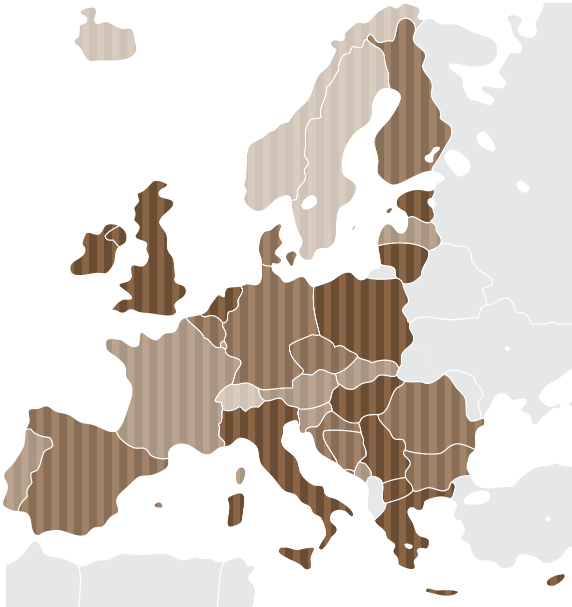
## Scenario A, B

The LCP Directive [11], which forces generators to shut down old fossil fuel power plants (under certain conditions) seems to have a deeper influence on Scenario A. Indeed, with this Scenario the decrease from 468 GW to 446 GW in 2020 is foreseen after 2015. It can also be formulated that, in Scenario B, the TSOs do not expect such a large scale of fossil fuel plant decommissioning due to the LCP Directive. It may well be possible that they also expect some older fossil fuel units to remain in operation (probably after some reconstruction in order to fulfil environmental limits).

Individual fossil fuel shares in NGC in Scenario B (in January) are depicted, by country, in Figure 3.2.2.5 and Figure 3.2.2.6. In both 2013 and 2020, the countries with the highest levels of fossil fuels are the Netherlands, Cyprus, Estonia and Poland.

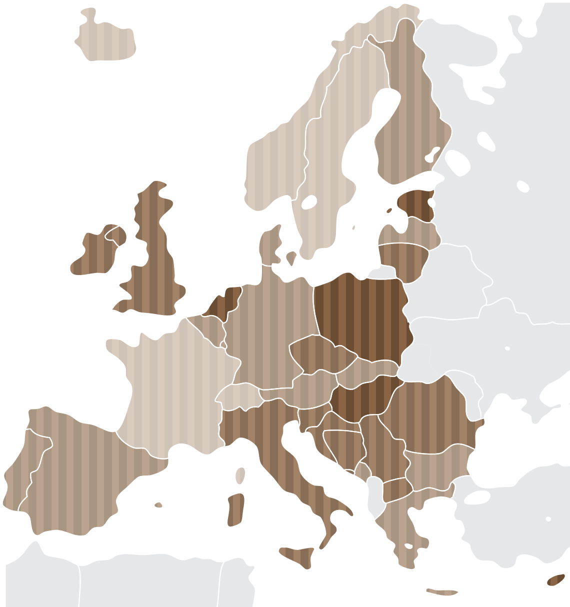
Independent of Scenario (A or B) or season (January or July), for 2013 – 2020 period, forecast annual growth rate of hard coal based capacity is always negative, ranging between -1.3 % and -1.65 %. The same applies to lignite (between -0.7 % and -0.9 %) as well as oil and others (between -1.0 % and -1.7 %). On the contrary, natural gas fuelled power plants are to spread. In the case of Scenario B, total gas capacity increases by approximately 30 GW (annual growth around 2 %). In Scenario A, this amount is lower, at only 6 GW.

[11] Directive 2001/80/EC on the limitation of emissions of certain pollutants into the air from large combustion plants



ENTSO-E average: 47 % | < 20 % | ≥ 20 % & < 40 % | ≥ 40 % & < 60 % | ≥ 60 %

Figure 3.2.2.5:
fossil fuels installed capacity as a part of NGC per country in 2013; Scenario B; January 7 p.m.



ENTSO-E average: 40 % | < 20 % | ≥ 20 % & < 40 % | ≥ 40 % & < 60 % | ≥ 60 %

Figure 3.2.2.6:
fossil fuels installed capacity as a part of NGC per country in 2020; Scenario B; January 7 p.m.

| | Scenario | 2013 – 2020 | Hard coal | Lignite | Gas | Oil and other |
|---|---|---|---|---|---|---|
| January 7 p.m. | A | [GW, total] | -12 | -3 | 5 | -10 |
| | | [%, yearly] | -1.47 % | -0.71 % | 0.37 % | -1.66 % |
| | B | [GW, total] | -13 | -4 | 28 | -8 |
| | | [%, yearly] | -1.65 % | -0.90 % | 1.99 % | -1.18 % |
| July 11 a.m. | A | [GW, total] | -11 | -3 | 6 | -11 |
| | | [%, yearly] | -1.32 % | -0.69 % | 0.46 % | -1.67 % |
| | B | [GW, total] | -12 | -4 | 29 | -6 |
| | | [%, yearly] | -1.50 % | -0.88 % | 2.06 % | -1.00 % |

Table 3.2.2.1:
ENTSO-E fossil fuels subcategories evolution for Scenarios A and B

## Scenario EU 2020

In Scenario EU 2020, as shown in Figure 3.2.2.7 (in January, 2020), Cyprus is the only country with more than 75 % of fossil fuels installed capacity, followed by Poland (72 %) and Estonia (71 %).

| | Scenario EU 2020 to Scenario B | Hard coal | Lignite | Gas | Oil and other |
|---|---|---|---|---|---|
| January 7 p.m. | [GW] | -4 | -1 | 5 | -10 |
| | [%] | -3.68 % | -2.14 % | 2.42 % | -11.99 % |
| July 11 a.m | [GW] | -4 | -1 | 4 | -12 |
| | [%] | -3.50 % | -2.49 % | 1.99 % | -13.00 % |

Table 3.2.2.2:
Differences of ENTSO-E fossil fuels subcategories in Scenario EU 2020 with relation to Scenario B

Compared to Scenario B, the major differences of Scenario EU 2020 lie in higher levels of gas based capacity, with additional 5 GW (i.e. an increase of between 2 % and 2.4 %, depending on season). In the case of remaining fuels, smaller values are observed, particularly in oil and other categories, by up to 12 GW (-12 % to -13 %).

## Scenario Vision 1 and Vision 3

Despite the decrease of fossil fuels share in the NGC of Vision 3 with relation to Vision 1, in absolute values, this category is higher in Vision 3 by more than 27 GW (see Table 3.2.2.3).

| | Vision 3 to Vision 1 | |
|---|---|---|
| | [%] | [GW] |
| January 7 p.m. | 6.26 % | 27.11 |
| July 11 a.m. | 6.38 % | 27.74 |

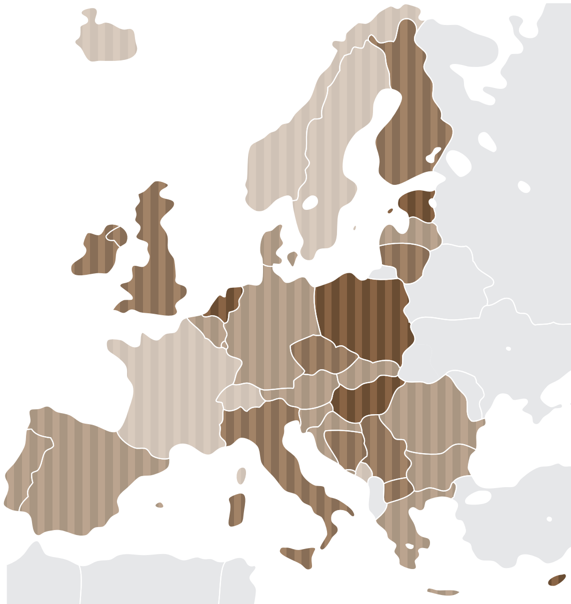
Table 3.2.2.3:
Difference of ENTSO-E fossil fuels generation capacity in Vision 3 with relation to Vision 1

Another way of addressing the differences between Vision 1 and Vision 3 is to show them as a proportion of the NGC of Scenario B in 2013, and of Vision 1 (in 2030), depicted in Table 3.2.2.4.

| | Vision 3 to Vision 1 as part of NGC in Scenario B 2013 | Vision 3 to Vision 1 as part of NGC in Vision 1 |
|---|---|---|
| | [%] | [%] |
| January 7 p.m. | 2.72 % | 2.28 % |
| July 11 a.m. | 2.76 % | 2.33 % |

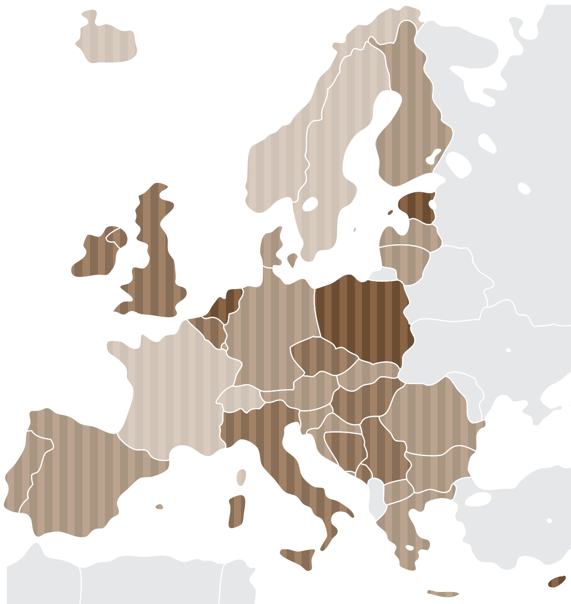
Table 3.2.2.4:
Differences of ENTSO-E fossil fuels generation capacity in Vision 3 with relation to Vision 1 as part of total NGC

In the long run, only Estonia is forecasting more than 75 % of installed capacity based on fossil fuels, in Vision 1. This share is to decrease to 61 % in Vision 3. In Vision 3, countries generally have a smaller fossil capacity share, compared to Vision 1.



ENTSO-E average: 38 % < 20 % ≥ 20 % & < 40 % ≥ 40 % & < 60 % ≥ 60 %

Figure 3.2.2.7:
fossil fuels installed capacity as a part of NGC per country in 2020; Scenario EU 2020; January 7 p.m.



ENTSO-E average: 36 % < 20 % ≥ 20 % & < 40 % ≥ 40 % & < 60 % ≥ 60 %

Figure 3.2.2.8:
fossil fuels installed capacity as a part of NGC per country in 2030; Vision 1; January 7 p.m.

This is particularly the case for Denmark (-74 %), Montenegro (-31 %), Austria (-28 %), Iceland (-28 %) and Sweden (-26 %). Exceptions include Switzerland, France, Romania, Luxemburg and Lithuania.

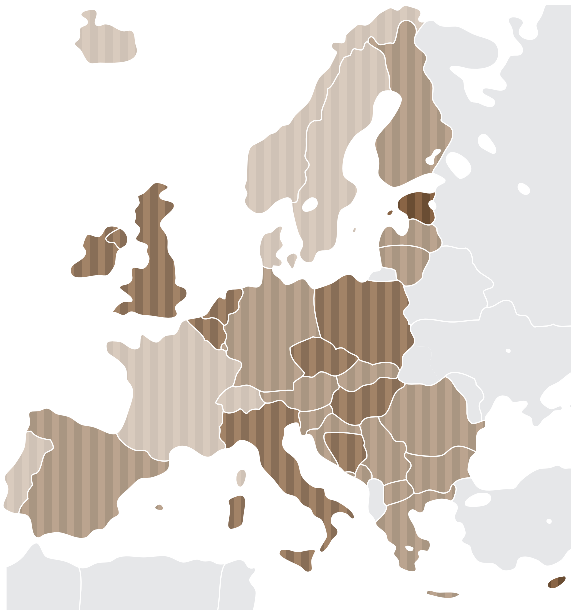



Figure 3.2.2.9:
fossil fuels installed capacity as a part of NGC per country in 2030; Vision 3; January 7 p.m.

## 3.2.3 Nuclear Generation Capacity

### Review of all Scenarios

Nuclear power plants are expected to increase the installed capacity until 2015. Following this, there is a decrease until 2020, when a similar level as in 2013 is forecast for ENTSO-E (between 123 GW and 125 GW). In the long run, national views reflect the growing public opposition to this technology, meaning that there is a general trend to decrease, with Vision 3 reaching 106 GW (the lowest level) and Vision 1 having a slightly higher capacity of 112 GW.

### Scenarios A, B

Comparing the previous Scenario B of the SO&AF 2011 and SO&AF 2012 (see Figure 3.2.3.2), major differences in nuclear capacity are mainly due to the German government's decision to gradually shut down their nuclear power plants. New updated forecasts point to a further decrease in 2020 (-6 %) at the ENTSO-E level, down to 125 GW. The main reasons behind this decrease pertain to the reductions reported in Great Britain (-2.9 GW), France (-2 GW), Finland (-1.6 GW), Lithuania (-1.4 GW) and Bulgaria (-1 GW). In Belgium the nuclear installed capacity is 1 GW higher than that

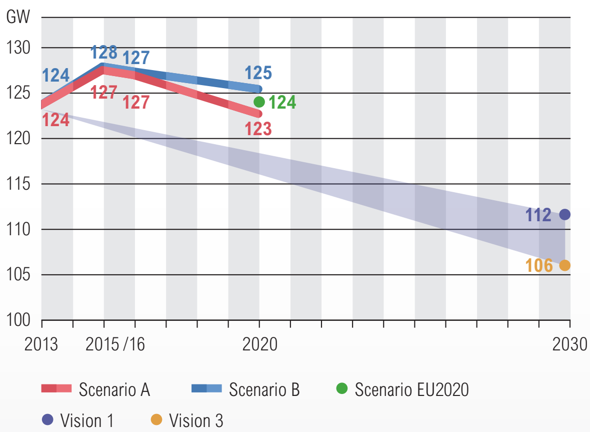



Figure 3.2.3.1:
ENTSO-E Nuclear generation capacity forecast; all Scenarios; January 7 p.m.

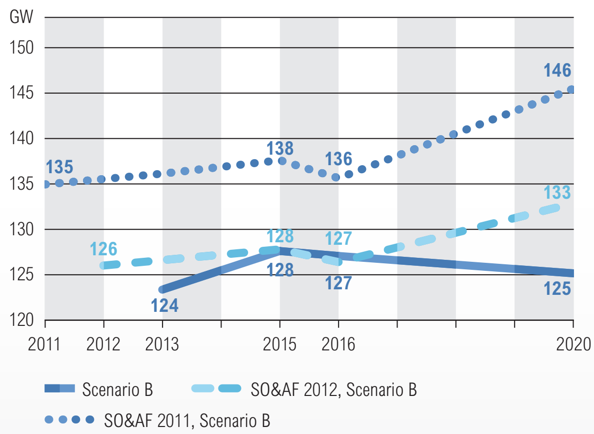



Figure 3.2.3.2:
Comparison of Nuclear generation capacity between SO&AF 2011, SO&AF 2012 and SO&AF 2013; scenario B; January 7 p.m.

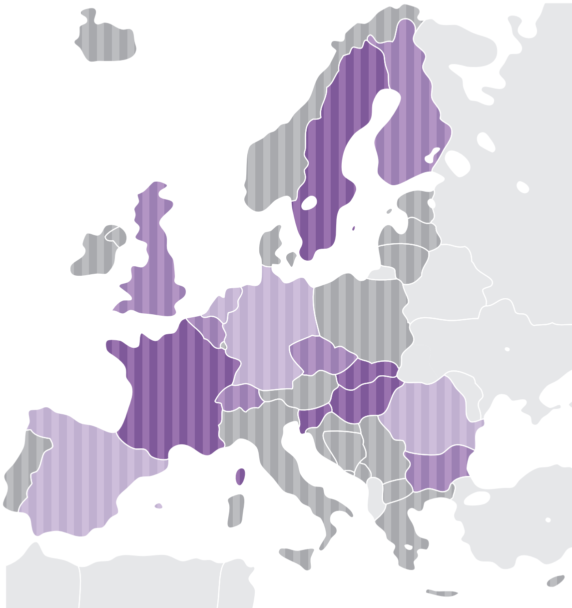



Figure 3.2.3.3:
Nuclear installed capacity as a part of NGC per country in 2013; scenario B; January 7 p.m.

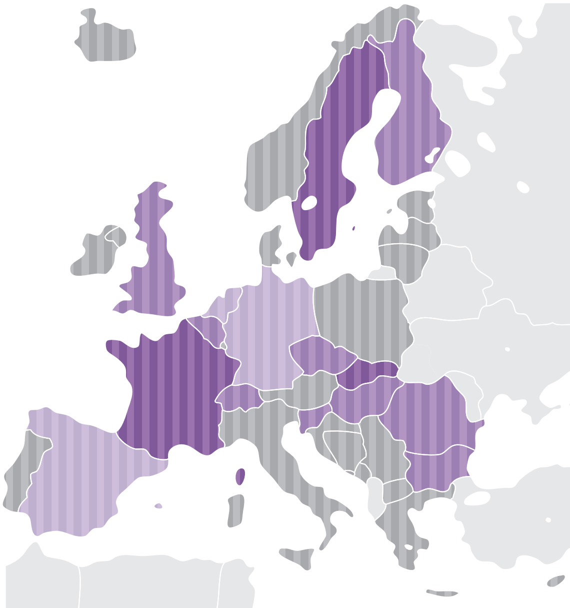



Figure 3.2.3.4:
Nuclear installed capacity as a part of NGC per country in 2020; Scenario B; January 7 p.m.

reported in the SO&AF 2012. A revision of the nuclear phase-out is currently under discussion in Belgium. This would result in a 10 year postponement of the nuclear phase out of one unit (1 GW). This adaptation is taken into account because the realisation is judged as very probable.

In terms of nuclear weight in the NGC, in Scenario B (see Figure 3.2.3.3), there is not much to report, except that France will maintain its leading position with more than a 45% share in 2020 whilst from 2013 to 2020, Slovakia will be over 25%.

### Scenario EU 2020

The situation in Scenario EU 2020 is very similar to that of Scenario B, which confirms that national policy views and TSO estimates are coherent when it comes to the nuclear issue. All countries are in the same range as shown on the map for Scenario B, with the only difference being that the ENTSO-E wide average is approximately 0.5 percentage points lower in EU 2020 scenario, mainly due to the slightly higher total NGC, and practically identical nuclear capacity forecasts.

### Scenario Vision 1 and Vision 3

Both Vision 1 and Vision 3 show absolute decreases of nuclear capacity, ranging from -11% to -16% of nuclear in Scenario B, as of 2020. Nevertheless, the decrease is more moderate in Vision 1 compared to Vision 3, which is proven by the differences shown in Table 3.3.2.1. Moreover, the 112 GW of

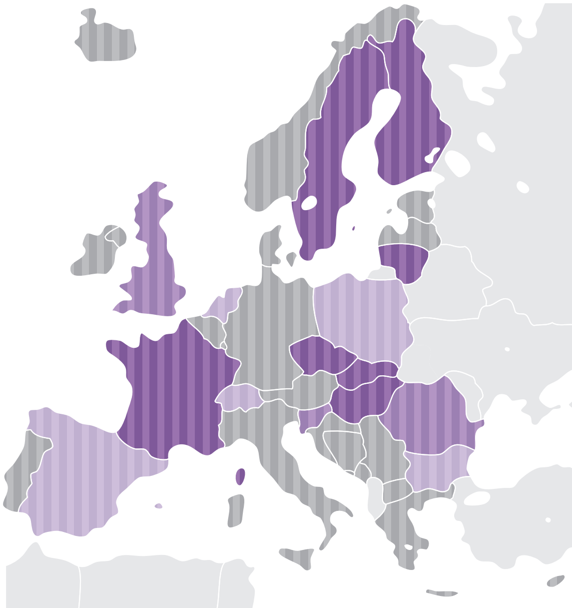



Figure 3.2.3.5:
Nuclear installed capacity as a part of NGC per country in 2030; Vision 1; January 7 p.m.

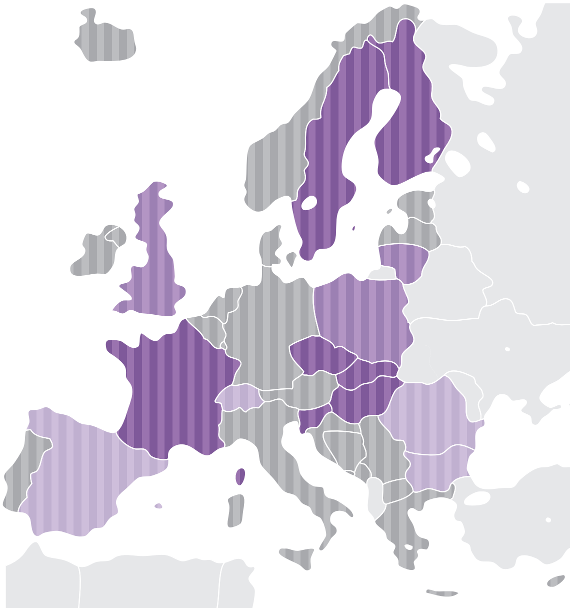



Figure 3.2.3.6:
Nuclear installed capacity as a part of NGC per country in 2030; Vision 3; January 7 p.m.

nuclear installed capacity forecast in Vision 1 represents 9 % of NGC against 7 % in Vision 3.

In Table 3.3.2.2 the differences between Vision 1 and Vision 3 are shown in terms of proportion of whole generation of both Scenario B in 2013 and Vision 1 (in 2030).

In Vision 1, France is to reduce its nuclear share in NGC to 43 % (-6 pp compared to Scenario B in 2013). On the contrary, and as shown in Figure 3.2.3.6, 3 countries are to join the leading group (due to new investments) with more than a 25 % share: Czech Republic (27 %), Hungary (27 %) and Lithuania (26 %).

In Vision 3, compared to Vision 1, while France is considering further decreases of nuclear share in NGC down to 24 %, other countries such as Slovenia (34 %) along with Hungary (32 %), Czech Republic (30 %) and Bulgaria (10 %) are increasing the proportion of this category.

| | **Vision 3 to Vision 1** | |
|---|---|---|
| | [%] | [GW] |
| January 7 p.m. | -5.08 % | -5.67 |
| July 11 a.m. | -5.08 % | -5.67 |

Table 3.2.3.1:
Difference of ENTSO-E Nuclear generation capacity in Vision 3 with relation to Vision 1

| | **Vision 3 to Vision 1 as part of NGC in Scenario B 2013** | **Vision 3 to Vision 1 as part of NGC in Vision 1** |
|---|---|---|
| | [%] | [%] |
| January 7 p.m. | -0.57 % | -0.48 % |
| July 11 a.m. | -0.56 % | -0.48 % |

Table 3.2.3.2:
Differences of ENTSO-E Nuclear generation capacity in Vision 3 with relation to Vision 1 as part of total NGC

## 3.2.4 Renewable Energy Sources (RES)

### Review of all Scenarios

As a result of the European energy and climate policy, the RES-category is expected to be the fastest growing production type. From a 2013 level of around 340 GW of installed capacity, it is expected that total RES in the year 2020 will reach a level of more than 500 GW, growing even further towards 2030.

In this chapter, renewable energy sources (described "RES"), including renewable hydro power plants (thereinafter as "HPP"), are assessed and are jointly referred to as "total RES". However, evaluations, statements and maps in this paragraph may be slightly biased, as it is not straightforward to divide total hydro power plants' installed capacity into requested sub-categories in every country's individual case, thus making the proper distinction between individual sub-categories of hydro power plants impossible. The main issue is for TSOs to identify the renewable generating capacity in hydro power units which combine the possibility of pump storage with natural inflow (pure pump storage is not recognised as RES). Hence, TSOs are not always able to identify whether or not the hydro capacity can be classified as RES capacity, although this is not true for actual generation. When the result or evaluation in the text is influenced by this fact, the reader is warned early. As RES HPP, the run-of-river and natural inflow storage HPP are considered, which can be applied for most of the ENTSO-E countries. Pure pumped storage HPP and the pumping part of mixed natural inflow and pump storage power plants are classified as non-RES HPP.

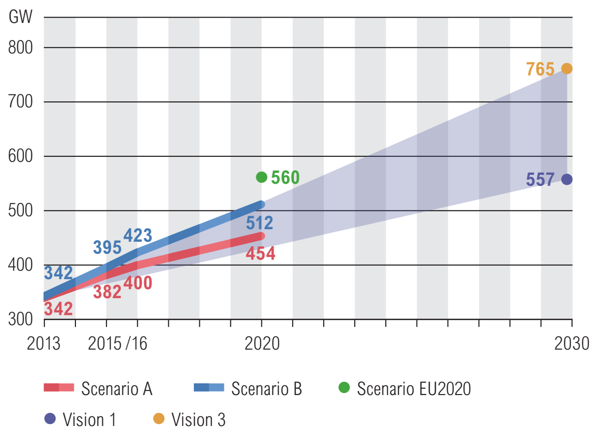



Figure 3.2.4.1:
ENTSO-E RES generation capacity forecast; all Scenarios; January 7 p.m.

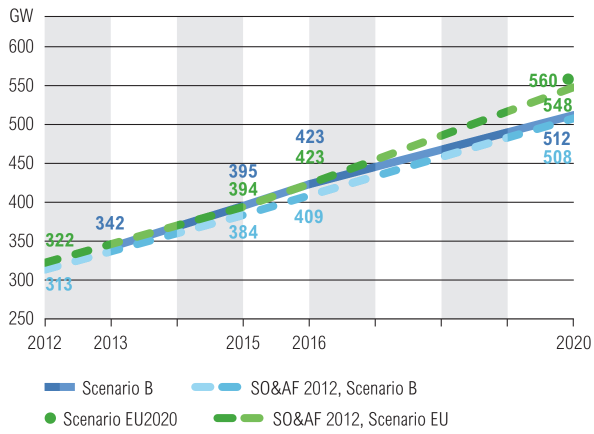



Figure 3.2.4.2:
Comparison of RES generation capacity between SO&AF 2012 and SO&AF 2013; Scenarios B and EU 2020; January 7 p.m.

Figure 3.2.4.1 shows the evolution of total RES installed capacity in the different Scenarios. From a level of 342 GW in 2013, it grows to 512 GW in Scenario B and 560 GW in Scenario EU 2020. Towards 2030, the different Visions reflect the major difference between different renewable policies. In Vision 1, the general guidelines assume that no new policies are put in place to stimulate RES, thus resulting in no expected new renewable capacity after 2020. Conversely, in Vision 3 the political goals are continued towards new goals for 2030 and are in line with the EU objectives for 2050. As a result of this, more than 200 GW of extra renewable capacities are built between 2020 and 2030 in Vision 3.

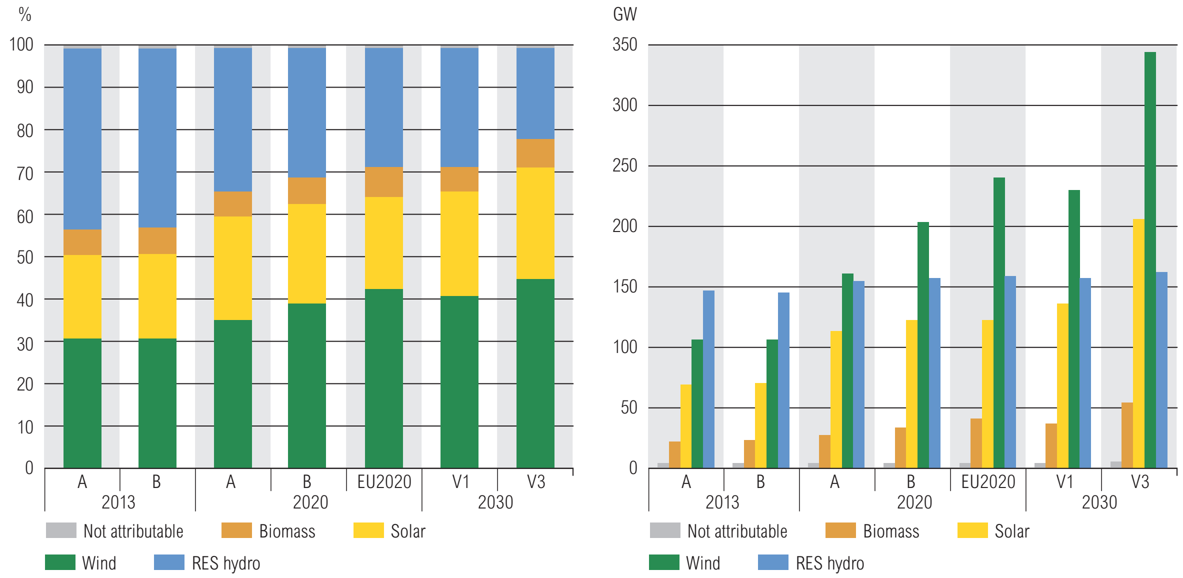



Figure 3.2.4.3:
ENTSO-E RES generation capacity breakdown in 2013, 2020 and 2030; all Scenarios; January 7 p.m. (ratios and absolute values)

Comparing the RES development for SO&AF 2013 with SO&AF 2012, it is evident that the European TSOs have become more optimistic over the last year regarding whether or not the 202020 policy goals will be fulfilled. This is shown in figure 3.2.4.2 when comparing Scenario B (Best Estimate) for SO&AF 2012 and SO&AF 2013. However, the Best Estimate Scenario also shows that a belief remains that the 202020-goals will be challenging to meet on time. This assumption is reflected in Vision 1, were the goals set for 2020 are met with a delay.

When looking at the RES generation capacity breakdown (relative values) in 2013, 2020 and 2030 (figure 3.2.4.3) there are two main observations. The first is that the wind share is growing rapidly. Secondly, the relative share of hydro within RES is considerably reduced. The absolute hydro-values are the same, although when compared to the fast growing RES-sector, their relative share is decreasing. This may well be a warning for the operation of the power systems, as wind and solar units do not have the necessary flexibility to balance the power system, which some hydro is able to provide.

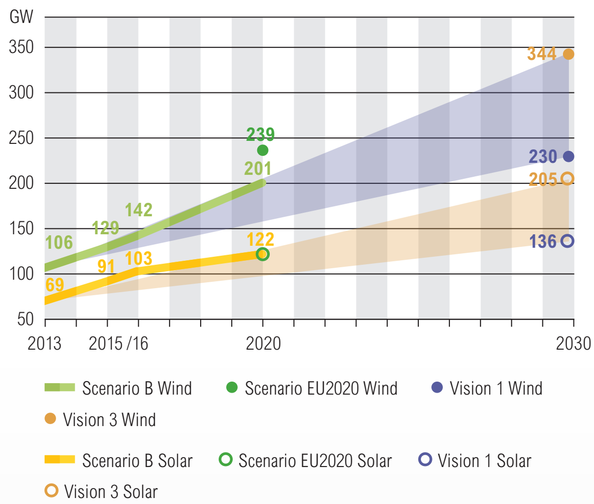
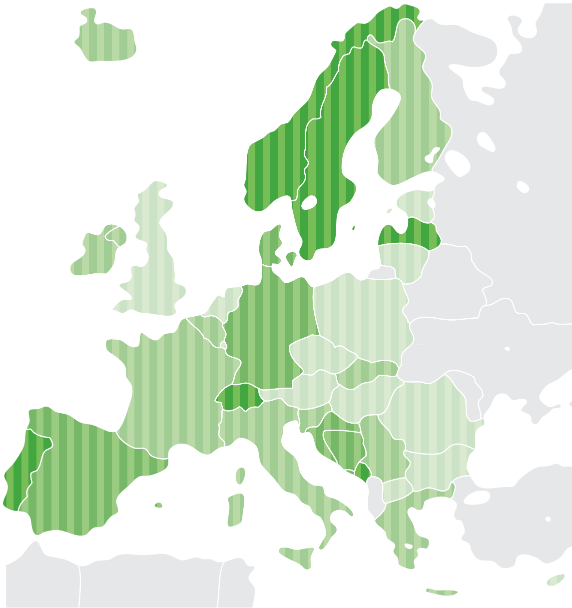



Figure 3.2.4.4:
ENTSO-E Wind and Solar generation capacity forecast; all Scenarios; January 7 p.m.

Among the different RES energy types, the different Scenarios/V isions show that wind capacity is the fastest growing type, followed by solar. A comparison of these two RES-types is shown in Figure 3.2.4.4. Wind is expected to grow from the 2013 foreseen capacity of 106 GW, to a 2030 level



ENTSO-E average: 34 % | < 20 % | ≥ 20 % & < 40 % | ≥ 40 % & < 60 % | ≥ 60 %

Figure 3.2.4.5:
RES installed capacity as a part of NGC per country in 2013; Scenario B; January 7 p.m

ENTSO-E average: 43 % | < 20 % | ≥ 20 % & < 40 % | ≥ 40 % & < 60 % | ≥ 60 %

Figure 3.2.4.6:
RES installed capacity as a part of NGC per country in 2020; Scenario B; January 7 p.m.

of between 230 GW (Vision 1) and 344 GW (Vision 3). Solar is expected to grow from a capacity of 70 GW in 2013 to a 2030 level of between 140 GW (Vision 1) and 200 GW (Vision 3). This reflects the installed capacity level, expressed as power. With regards to energy production, the utilisation time is almost three times higher for wind than for solar. This means that the energy from wind power will be much higher than the energy from solar power.

## Scenario A, B

Figure 3.2.4.6 shows the share of RES as part of the total NGC of each ENTSO-E country for Scenario B in 2020. The total RES capacity is expected to be 512 GW, which is 43 % of the total NGC. The majority of the countries show a lower share of total RES than the ENTSO-E average. Norway (96 %) and Switzerland (73 %) are the countries with the highest share of RES in NGC. Among other countries with a higher share of total RES in their NGC mix than the ENTSO-E average, one can count mainly Montenegro, Sweden, Denmark, Latvia and Portugal, as well as Croatia, Northern Ireland, Germany, Spain and Greece.

The RES development for different production types is shown in Table 3.2.4.1. For the years 2013 – 2020, Scenario B shows that wind is expected to exhibit an annual growth of 9.5 % (total 95 GW). In addition, solar is expected to grow by an annual rate of 8 % (total 50 GW), whilst biomass is expected to grow 6 % each year (total 12 GW) and RES hydro by 1 % yearly (total 10 GW).

| | Scenario | 2013–2020 | Wind | Solar* | Biomass | RES hydro |
|---|---|---|---|---|---|---|
| January 7 p.m. | A | [GW, total] | 55 | 45 | 6 | 8 |
| | | [%, yearly] | 6.24 % | 7.47 % | 3.74 % | 0.77 % |
| | B | [GW, total] | 95 | 53 | 12 | 10 |
| | | [%, yearly] | 9.59 % | 8.41 % | 6.43 % | 0.96 % |
| July 11 a.m. | A | [GW, total] | 54 | 42 | 6 | 8 |
| | | [%, yearly] | 5.96 % | 6.83 % | 3.69 % | 0.74 % |
| | B | [GW, total] | 96 | 49 | 12 | 10 |
| | | [%, yearly] | 9.45 % | 7.60 % | 6.43 % | 0.94 % |

Table 3.2.4.1:
ENTSO-E RES subcategories evolution for Scenarios A and B
* Values for January, 7 pm reference point are merely for information on installed capacity

## Scenario EU 2020

Figure 3.2.4.7 shows the share of RES as part of the total NGC for each ENTSO-E country for Scenario EU 2020. The RES capacity is expected to total 560 GW, which is 46 % of the total NGC. The majority of the countries show a lower share of total RES than the ENTSO-E average. Norway (96 %) is the country with the highest share of RES in NGC. Among other countries with a higher share of total RES in their NGC mix than the ENTSO-E average, one can count mainly Montenegro, Denmark, Latvia, Portugal, Sweden and Switzerland, as well as Germany, Spain, Croatia, Northern Ireland and Greece.

The difference between RES development for Scenario B and Scenario EU 2020 for different production types is shown in Table 3.2.4.2. The biggest difference for the two Scenarios is for wind, where Scenario EU 2020 shows an estimate of 40 GW more wind than in Scenario B. Moreover, for the Biomass and RES hydro part, Scenario EU 2020 shows a belief in higher values than in Scenario B.

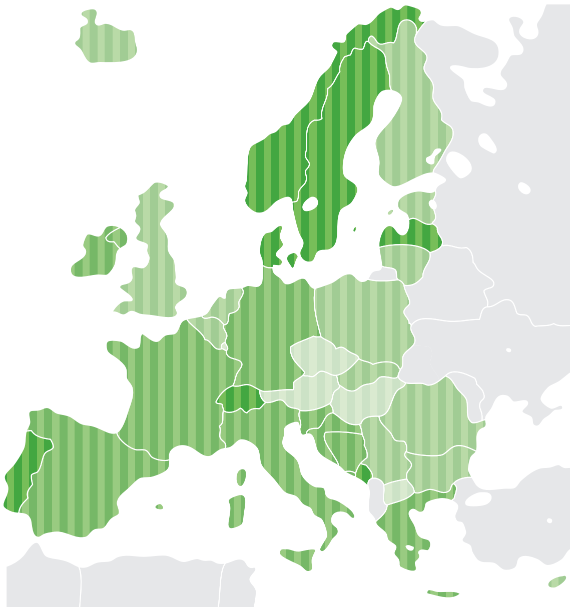



Figure 3.2.4.7:
RES installed capacity as a part of NGC per country in 2020; Scenario EU 2020; January 7 p.m.

| | Scenario EU 2020 to Scenario B | Wind | Solar | Biomass | RES hydro |
|---|---|---|---|---|---|
| January 7 p.m. | [GW] | 38 | 0 | 7 | 3 |
| | [%] | 19.01 % | 0.02 % | 20.15 % | 1.87 % |
| July 11 a.m | [GW] | 43 | 0 | 7 | 3 |
| | [%] | 20.97 % | 0.18 % | 19.72 % | 1.87 % |

Table 3.2.4.2:
Differences of ENTSO-E RES subcategories in Scenario EU 2020 with relation to Scenario B

| | Vision 3 to Vision 1 | Total RES | Wind | Solar | Biomass | RES hydro |
|---|---|---|---|---|---|---|
| January 7 p.m. | [GW] | 207 | 114 | 69 | 18 | 5 |
| | [%] | 37.23 % | 49.61 % | 50.74 % | 51.65 % | 3.40 % |
| July 11 a.m | [GW] | 209 | 115 | 70 | 18 | 5 |
| | [%] | 37.44 % | 49.57 % | 51.19 % | 51.96 % | 3.41 % |

Table 3.2.4.3:
Difference of ENTSO-E RES generation capacity in Vision 3 with relation to Vision 1

| | Vision 3 to Vision 1 as part of NGC in Scenario B 2013 | Total RES | Wind | Solar | Biomass | RES hydro |
|---|---|---|---|---|---|---|
| January 7 p.m. | [%] | 20.81 % | 11.43 % | 6.91 % | 1.82 % | 0.53 % |
| July 11 a.m | [%] | 20.80 % | 11.40 % | 6.92 % | 1.81 % | 0.52 % |

Table 3.2.4.4:
Differences of ENTSO-E RES generation capacity in Vision 3 with relation to Vision 1 as part of total NGC

## Scenario Vision 1 and Vision 3

Figures 3.2.4.8 and 3.2.4.9 show the share of RES as part of the total NGC for each ENTSO-E country for the year 2030 for Vision 1 and Vision 3. With regards to Vision 1, the total RES capacity is expected to be 560 GW, which is 47 % of the total NGC. In terms of Vision 3, the total RES capacity is expected to be 765 GW, which is 53.5 % of the total NGC. The majority of the countries show a lower share of total RES than the ENTSO-E average. In Vision 3, Norway (97 %) and Denmark (90 %) are the countries with the


Figure 3.2.4.8:
RES installed capacity as a part of NGC per country in 2030; Vision 1; January 7 p.m.

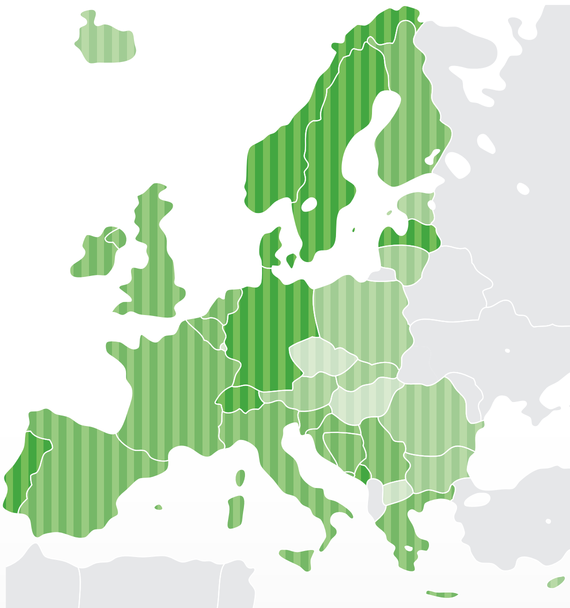



Figure 3.2.4.9:
RES installed capacity as a part of NGC per country in 2030; Vision 3; January 7 p.m.

highest share of RES in NGC. Among other countries with a higher share of total RES in their NGC mix than the ENTSO-E average, one can count mainly Sweden, Portugal, Latvia, Montenegro, Switzerland, Germany and France, together with Greece, Spain, Croatia and Northern Ireland.

The difference of RES generation capacity for Vision 1 and Vision 3 for different production types is shown in Table 3.2.4.3. In total, Vision 3 has more than 200 GW total RES capacity over that of Vision 1. The biggest difference between the two visions is for wind, where Vision 3 displays 114 GW higher figures. In addition, solar (69 GW), biomass (18 GW) and RES hydro (5 GW) all have a higher capacity in Vision 3 than in Vision 1.

## EU Energy Roadmap Indicators

The European Commission has indicated that the share of electricity from renewable energy sources is expected to be between 51.4 and 59.8 % for the EU by 2030 in order to remain on track for the EU energy roadmap 2050 (see table below[12]).

| | | | | Current trends | | Decarbonisation Scenarios | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2005 | Reference scenario | Current Policy Initiatives | High Energy Efficiency | Diversified Supply Technologies | High Renewables | Delayed CCS | Low nuclear |
| Primary energy demand reduction (in % from 2005)* | | 2030 | | -5.3 | -10.8 | -20.5 | -16 | -17.3 | -16.1 | -18.5 |
| | | 2050 | | -3.5 | -11.6 | -40.6 | -33.3 | -37.9 | -32.2 | -37.7 |
| Electrification | | 2030 | 20.2 | 25.1 | 24.5 | 25.2 | 26.0 | 25.4 | 26.0 | 25.7 |
| | | 2050 | - | 29.1 | 29.4 | 37.3 | 38.7 | 36.1 | 38.7 | 38.5 |
| Fuels (in %) | Renewables in gross final energy | 2030 | 8,6 | 23.9 | 24.7 | 27.6 | 27.7 | 31.2 | 28 | 28.8 |
| | | 2050 | - | 25.5 | 29 | 57.3 | 54.6 | 75.2 | 55.7 | 57.5 |
| | CCS in power generation | 2030 | 0 | 2.9 | 0.8 | 0.7 | 0.8 | 0.6 | 0.7 | 2.1 |
| | | 2050 | - | 17.8 | 7.6 | 20.5 | 24.2 | 6.9 | 19 | 31.9 |
| | Nuclear energy in primary energy | 2030 | 14,1 | 14.3 | 12.1 | 11.1 | 13.9 | 9.7 | 13.2 | 8.4 |
| | | 2050 | - | 16.7 | 13.5 | 13.5 | 15.3 | 3.8 | 17.5 | 2.6 |
| Fuels in electricity generation (in %) | RES | 2030 | 14.3 | 40.5 | 43.7 | 52.9 | 51.2 | 59.8 | 51.7 | 54.6 |
| | | 2050 | - | 40.3 | 48.8 | 64.2 | 59.1 | 86.4 | 60.7 | 64.8 |
| | CCS | 2030 | 0.0 | 2.9 | 0.8 | 0.7 | 0.8 | 0.6 | 0.7 | 2.1 |
| | | 2050 | - | 17.8 | 7.6 | 20.5 | 24.2 | 6.9 | 19.0 | 31.9 |
| | NUC | 2030 | 30.5 | 24.5 | 20.7 | 18.6 | 21.2 | 15.8 | 21.5 | 13.4 |
| | | 2050 | - | 26.4 | 20.6 | 14.2 | 16.1 | 3.6 | 19.2 | 2.5 |
| Average electricity prices (in EUR'08 per MWh, after tax)** | | 2030 | 109,3 | 154,8 | 156,0 | 154,4 | 159,6 | 164,4 | 160,4 | 168,2 |
| | | 2050 | - | 151,1 | 156,9 | 146,7 | 146,2 | 198,9 | 151,9 | 157,2 |
| Annual energy system costs related to GDP (in % 2011–2050) | | | - | 14.37 | 14.58 | 14.56 | 14.11 | 14.42 | 14.06 | 14.21 |
| Import dependency (in %) | | 2030 | 52,5 | 56.4 | 57.5 | 56.1 | 55.2 | 55.3 | 54.9 | 57.5 |
| | | 2050 | - | 57.6 | 58.0 | 39.7 | 39.7 | 35.1 | 38.8 | 45.1 |

*Results for primary energy consumption should not be confused with the energy saving targets for 2020 which is calculated against the projected consumption for 2020. Relating this savings objective to energy consumption in 2005, similar to the calculations in the Scenarios, would be equivalent to a saving target of 14% in 2020.
**The price projections ensure full recovery of costs associated with electricity supply in order to depict Scenarios in which the investment in production, storage, grids, taxes, etc are fully covered by revenues from selling electricity. In that sense they are not forecasts of future electricity prices, as systems may evolve, in which, contrary to the overall practice today, such investments are partly remunerated by other schemes.

Table 3.2.4.5:
Differences of ENTSO-E RES generation capacity in Vision 3 with relation to Vision 1 as part of total NGC

12) Source : http://ec.europa.eu/energy/renewables/electricity/electricity_en.htm

| | $CO_2$ indicator gas only | | | $CO_2$ indicator '09 mix | | | |
|---|---|---|---|---|---|---|---|
| | EU 2020 | Vision 1 2030 | Vision 3 2030 | EU 2020 | Vision 1 2030 | Vision 3 2030 | |
| ENTSO-E | 365,0 | 435,7 | 443, 9 | 689,5 | 823,0 | 838,5 | Mton |
| EU27 + HR | 346,6 | 415,6 | 424,4 | 654,7 | 785,1 | 801,6 | |
| ENTSO-E | 68 % | 62 % | 61 % | 40 % | 28 % | 27 % | Reduction from 1990 values |
| EU27 + HR | 69 % | 63 % | 62 % | 42 % | 30 % | 29 % | |

Table 3.2.4.6:
$CO_2$ emissions and reduction

The values shown in Table 3.2.4.7 have been calculated as described in the Methodology chapter of this document. As the results suggest, Vision 3 values fall within the given range, taking into account EU27 countries (and Croatia), although there is a very large spread across countries. In general, countries with a high level of RES hydro production have the highest values (very similar results are achieved for the entire ENTSO-E area).

| | Scenario EU 2020 | Vision 1 | Vision 3 |
|---|---|---|---|
| EU27+HR | 47 % | 45 % | 53 % |

Table 3.2.4.7:
EU energy roadmap RES energy indicator

In turn, Vision 1 values, as follows from the assumptions on this Vision is based, fall short of the values foreseen in order to be on track for the 2050 policy goals.

As seen in the table below, the 2030 Visions are in line with the 2030 intermediate values for the accomplishment of 2050 roadmap targets for power generation, if fossil generation is assumed to be only gas-based. This is true for both Visions, both when assessed for EU countries (including Croatia) and for the entire ENTSO-E.

However, the values, assuming that the 2009 generation mix is maintained, fall well short of the targets.

| **GHG reductions compared to 1990** | **2005** | **2030** | **2050** |
|---|---|---|---|
| **Total** | **-7 %** | **-40 to -44 %** | **-79 to -82 %** |
| **Sectors** | | | |
| Power ($CO_2$) | -7 % | -54 to -68 % | -93 to -99 % |
| Industry ($CO_2$) | -20 % | -34 to -40 % | -83 to -87 % |
| Transport (incl. $CO_2$ aviation, excl. maritime) | +30 % | +20 to -9 % | -54 to -67 % |
| *Surface Transport* | *+25 %* | *+8 to -17 %* | *-61 to -74 %* |
| Residential and services ($CO_2$) | -12 % | -37 to -53 % | -88 to-91 % |
| Agriculture (Non-$CO_2$) | -20 % | -36 to -37 % | -42 to -49 % |
| Other Non-$CO_2$ emissions | -30 % | -72 to -73 % | -70 to -78 % |

Table 3.2.4.8:
EU targets for $CO_2$ emission reductions for 2050 roadmap goals

## 3.2.5 Non-RES Hydro Power Plants (HPP)

### Review of all Scenarios

RES HPP, the run-of-river and natural inflow storage HPP are considered. In addition, non-RES HPP, pure pumped storage HPP and the pumping part of mixed natural inflow and pump storage power plants are also considered.

Figure 3.2.5.1 shows the evolution of total hydro power plants (HPP) installed capacity in the different Scenarios. From a level of 200 GW today it grows to 228 GW in Scenario EU 2020. Towards 2030, the different Visions reflect relatively small differences for hydro. In Vision 1, no new renewables are expected after 2020, while in Vision 3 the political goals continue towards new goals for 2030. However, for hydro in these two Visions, the difference is not expected to be high. In Vision 1, total hydro is expected to be 234 GW in 2030, while in Vision 3,246 GW is expected in 2030 (5 % higher).

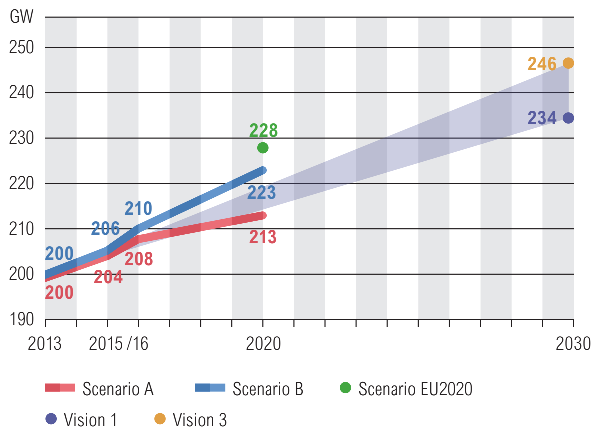



Figure 3.2.5.1:
ENTSO-E total HPP generation capacity forecast; all Scenarios; January 7 p.m.

A comparison of total HPP generation capacity for SO&AF 2012 and SO&AF 2013 (Figure 3.2.5.2) shows that the difference between the two years is very small. For all the years towards 2020, Scenario B shows that there is an expectation that the 202020-goals will not be fully met.

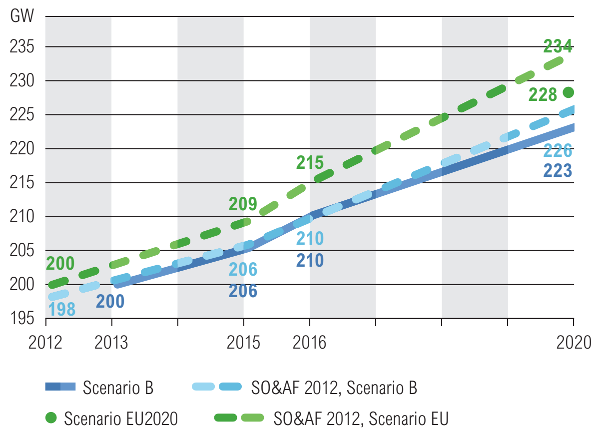



Figure 3.2.5.2:
Comparison of total HPP generation capacity between SO&AF 2012 and SO&AF 2013; Scenarios B and EU 2020; January 7 p.m.

In Scenario EU 2020, the installed capacity in the non-renewable hydro power plants (non-RES HPP) category is continuously increasing (Figure 4.4.3). The increase rate prior to 2015 is 9.5 % whilst between 2015 and 2020 it grows to 26 %. In both 2015 and 2020, the highest amount of non-RES HPP is reported in Austria and Germany.

Figure 3.2.5.3 shows the evolution of installed capacity of both RES hydro power plants and non-RES hydro power plants in the different Scenarios. Today, 28 % of the total hydro capacity is classified as non-RES hydro, while 72 % is RES-hydro. Towards 2030, it is expected that the relative share will move in the direction of more non-RES. This is due to the need for more flexibility in the power system, and therefore a need to develop hydro pump stations. In 2030 and Vision 3, 35 % of the total hydro is expected to be non-RES hydro, while 65 % is expected to be RES-hydro. The expected growth of non-RES hydro is also shown in Figure 3.2.5.4. This figure also shows a comparison of the development of non-RES HPP generation capacity between SO&AF 2012 and SO&AF 2013.

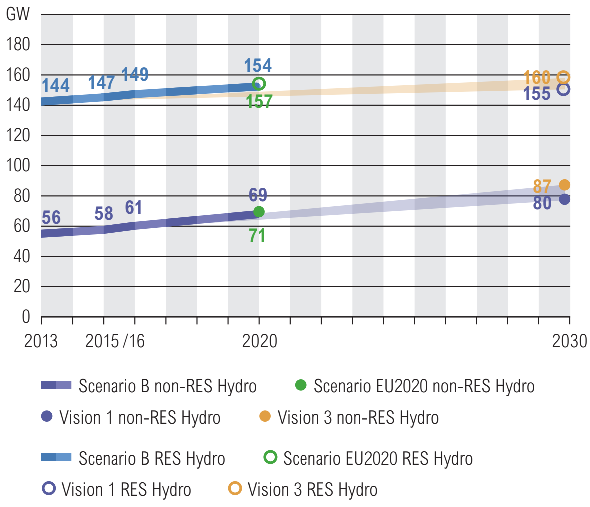



Figure 3.2.5.3:
ENTSO-E non-RES HPP generation capacity forecast; all Scenarios; January 7 p.m.

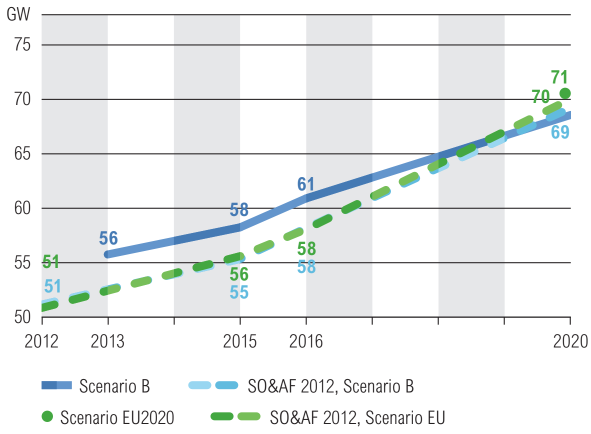



Figure 3.2.5.4:
Comparison of non-RES HPP generation capacity between SO&AF 2012 and SO&AF 2013; Scenarios B and EU 2020; January 7 p.m.

## Scenarios A, B

The share of total hydro (RES HPP + non-RES HPP) installed capacity as part of net generation capacity is shown for each country in Figure 3.2.5.5 (Scenario B). The figure demonstrates that the highest share in Scenario B is expected to be in Norway (89 %) and Switzerland (80 %), followed by Iceland, Luxembourg, Montenegro and Austria, with more than 50 % NGC in HPP.

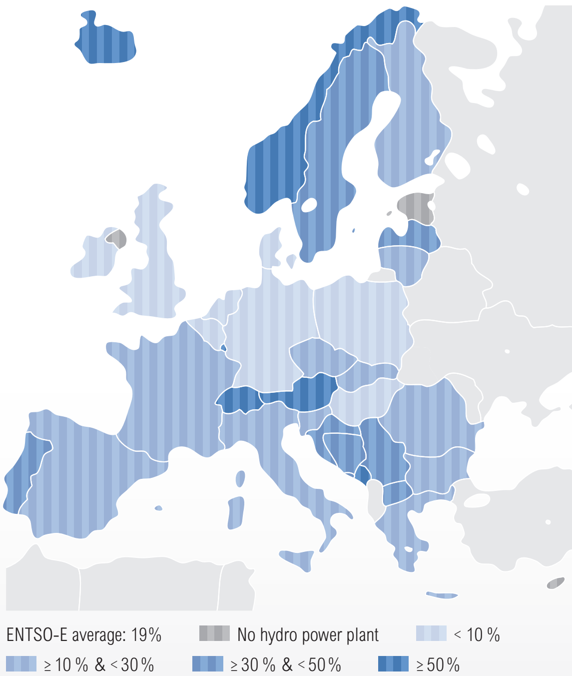



Figure 3.2.5.5:
Total HPP installed capacity as a part of NGC per country in 2020; Scenario B; January 7 p.m.

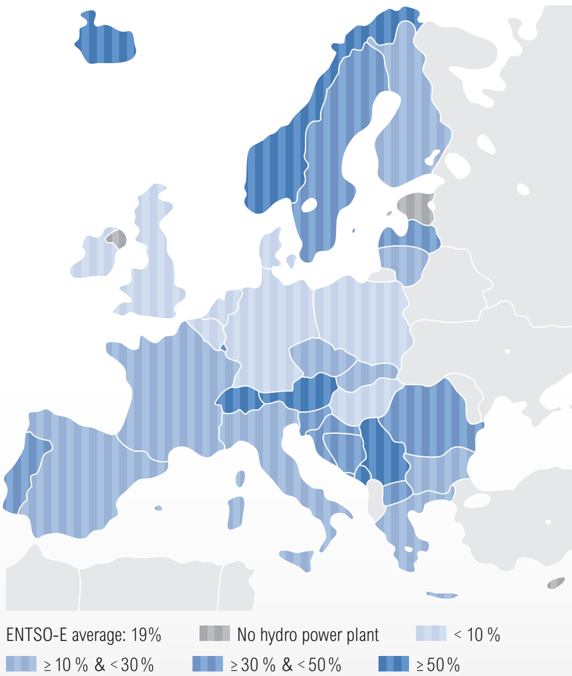



Figure 3.2.5.6:
Total HPP installed capacity as a part of NGC per country in 2020; Scenario EU 2020; January 7 p.m.

## Scenario EU 2020

In Figure 3.2.5.6, the share of total hydro (RES HPP + non-RES HPP) installed capacity as part of net generation capacity is shown for each country for Scenario EU 2020. The figure shows that the countries with the highest share are expected to be Norway (89 %) and Switzerland (74 %), followed by Iceland, Montenegro, Luxembourg, Austria and Serbia with more than 50 % NGC in HPP.

| | Vision 3 to Vision 1 | Total hydro | non-RES hydro | RES hydro |
|---|---|---|---|---|
| January 7 p.m. | [GW] | 12 | 7 | 5 |
| | [%] | 5.24 % | 8.81 % | 3.40 % |
| July 11 a.m | [GW] | 12 | 7 | 5 |
| | [%] | 5.20 % | 8.69 % | 3.41 % |

Table 3.2.5.1:
Difference of ENTSO-E HPP generation capacity in Vision 3 with relation to Vision 1

| | Vision 3 to Vision 1 as part of NGC in Scenario B 2013 | Total hydro | non-RES hydro | RES hydro |
|---|---|---|---|---|
| January 7 p.m. | [%] | 1.23 % | 0.70 % | 0.53 % |
| July 11 a.m | [%] | 1.21 % | 0.69 % | 0.52 % |

Table 3.2.5.2:
Differences of ENTSO-E HPP generation capacity in Vision 3 with relation to Vision 1 as part of total NGC

## Scenario Vision 1 and Vision 3

Table 3.2.5.1 shows the difference of hydro generation capacity in Vision 3, compared to Vision 1. As shown in the table, the total hydro capacity is 5 % higher in Vision 3 than in Vision 1. The non-RES hydro in particular (pump stations etc.) is higher for Vision 3. The reason for this is that this Vision is a "green vision", with a higher system need for flexible generation. In the forecast, pump stations are providing some of this flexibility. Furthermore, the guidelines for the 2030 Visions indicate that decentralised storage potential could be entered through an increase of the daily pure storage capacity.

Table 3.2.5.2 shows the difference of hydro generation capacity as part of net generation capacity in Vision 3 with relation to Vision 1. As shown in the table, the total hydro capacity as part of net generation capacity is 1 % higher in Vision 3 than in Vision 1.

Figures 3.2.5.7 and 3.2.5.8 show the share of total hydro (RES HPP + non-RES HPP) installed capacity as part of net generation capacity for each country, for Vision 1 and Vision 3 respectively. Similar to the other (2020) Scenarios, the figures show that the highest hydro-share is expected to be in Norway (89 % and 85 %) and Switzerland (82 % and 69 %), followed by Iceland, Luxembourg, Austria , Montenegro, Macedonia and Serbia with more than 50 % NGC in HPP.

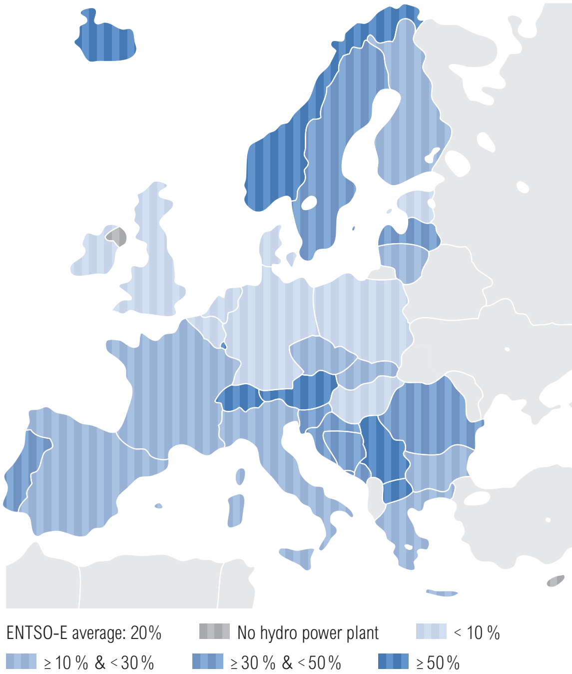



Figure 3.2.5.7:
Total HPP installed capacity as a part of NGC per country in 2020; Vision 1; January 7 p.m.

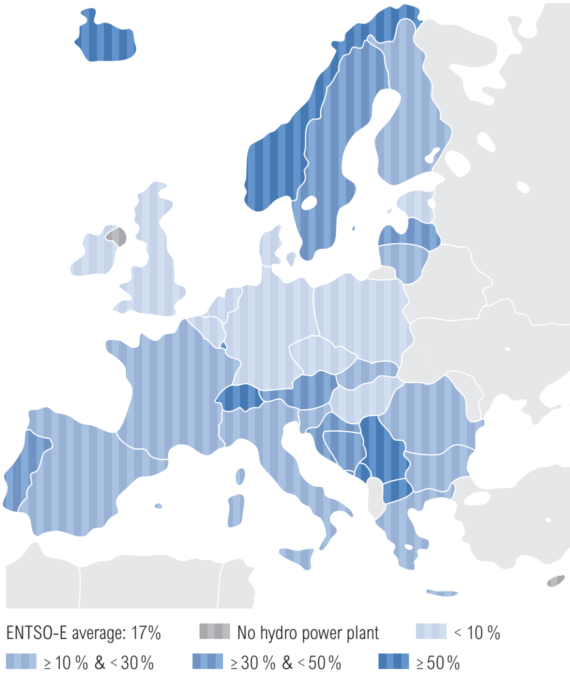



Figure 3.2.5.8:
Total HPP installed capacity as a part of NGC per country in 2020; Vision 3; January 7 p.m.

# 3.3 Unavailable Capacity (UC) & Reliable Available Capacity (RAC)

## Comparison of all Scenarios

The following two figures compare the evolution of Unavailable Capacity (UC) as a ratio of NGC, under different Scenarios. In both the winter and

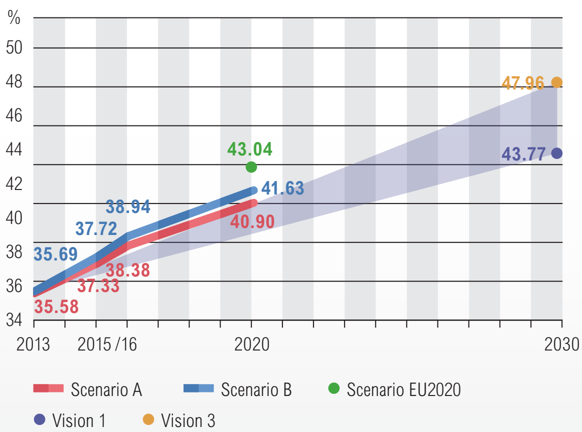



Figure 3.3.1:
ENTSO-E UC as a part of NGC, January

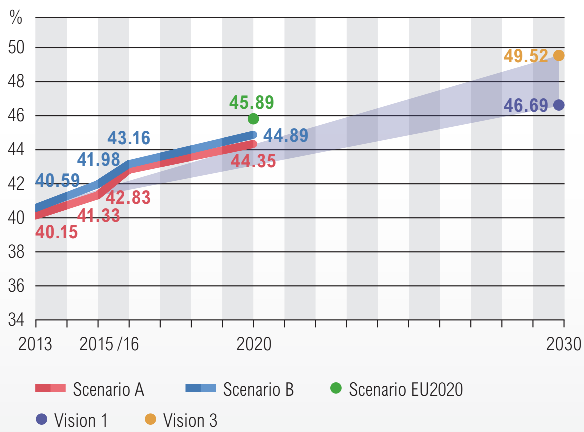



Figure 3.3.2:
ENTSO-E UC as a part of NGC, July

summer reference points, Scenario B values are above those for Scenario A, while in 2020, full compliance with the EU 202020 goals would correspond to the highest share of UC. This is most likely explained by the strong link between RES penetration level in the generation mix and UC share.

All corresponding UC ratios are slightly higher for the summer reference point, which is caused both by the typical annual distribution of maintenance schedules as well as the generally higher share of RES-E. This is particularly so for solar capacity in the summer period due to the selection of the reference point in the summer at 11 a.m. in contrast with the winter at 7 p.m. (after sunset).

Under both evaluated Scenarios for 2030, the increase in the rate of UC continues between 2020 and 2030, although the rate is slower by 2020.

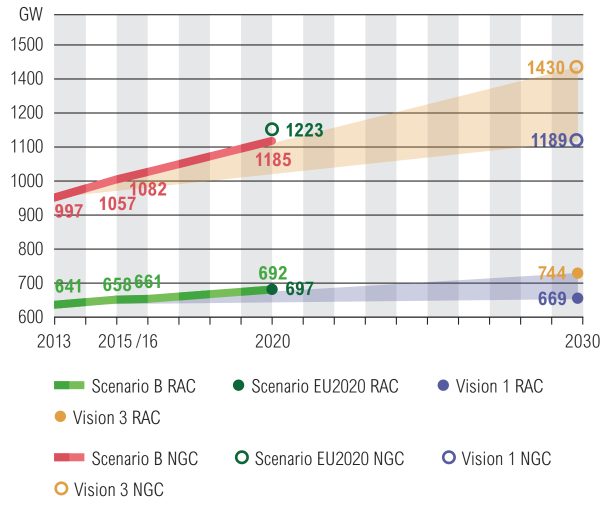
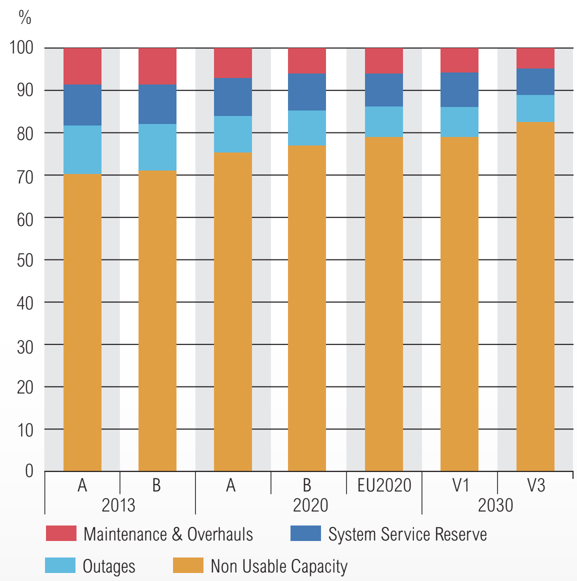



Figure 3.3.3:
ENTSO-E NGC & RAC forecast in Scenarios B, EU 2020 and Visions, January

In the following part of this chapter, only January figures will be shown, as the trends are also very similar for the July reference point.

When comparing the rate of growth of NGC and RAC absolute values (below), it is clear that RAC growth rates are lower, directly corresponding to the increasing ratio of UC as seen previously.

When assessing the composition of factors contributing to UC (below), it can be observed that in absolute values, outages remain nearly constant over the assessed period despite increasing NGC capacities. This is due to the expected gradual modernisation of the fleet. Maintenance and over-



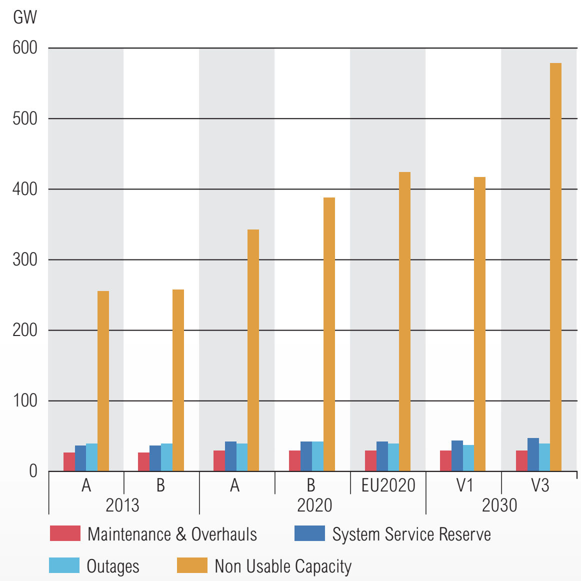




Figure 3.3.4:
ENTSO-E UC forecast, January

hauls, as well as system service reserves increase marginally; however, the main driver of the growth of unavailable capacity is clearly non-usable capacity. As described in the definitions, this figure may encompass generation capacity which is temporarily not available due to various constraints. Among these constraints we find power stations whose output power cannot be fully injected due to transmission constraints, as well as limitations reflecting the availability of the primary energy source, most characteristic of RES generation.

## Scenario A and B

When assessing the geographical variation in UC percentages, the following trends are observed:

- UC average ratio across ENTSO-E members increases monotonously in the order of Scenario B, EU20, Vision 1 and Vision 3, as presented below.
- In most Scenarios, the highest UC ratio matches well with the countries expecting to have the highest RES penetration levels.

The countries with the highest UC percentage in Scenarios B and EU20 are Denmark and Germany (above 60 %), followed by Spain and Italy (above 50 % in both Scenarios).

By 2020, the ENTSO-E average of unavailable capacity is forecast to increase to 41.6 % (from an estimated 35.7 % in 2013). This is clearly due to the more rapid increase of UC (and within that, non-usable capacity, as seen above) when compared to the relatively slower growth of RAC. This can be clearly explained by the fact that the rapid-growing renewable generation capacity (especially wind and solar) has a much lower availability factor than other generation types.

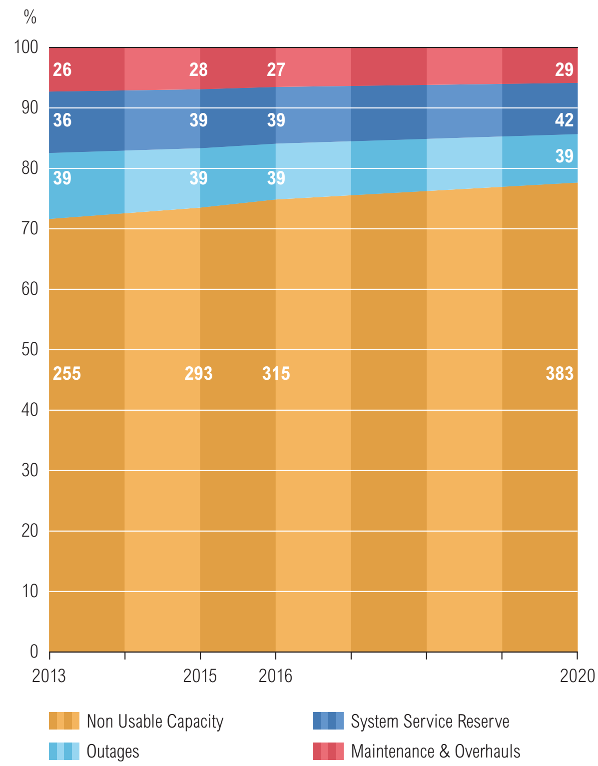



Figure 3.3.5:
ENTSO-E UC mix, Scenario B, January

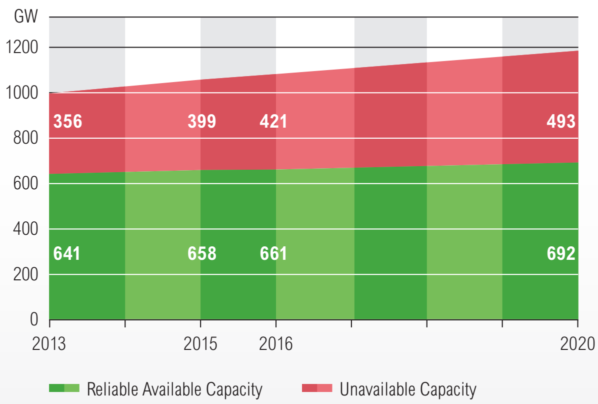
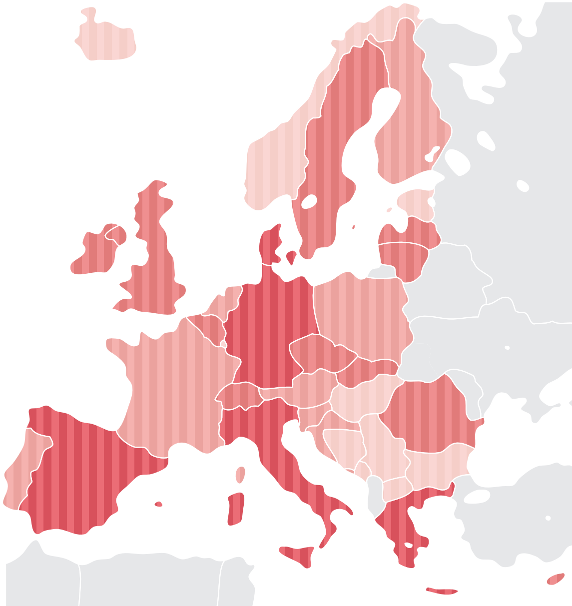



Figure 3.3.6:
UC and RAC development forecast, Scenario B, January

## Scenario EU 2020

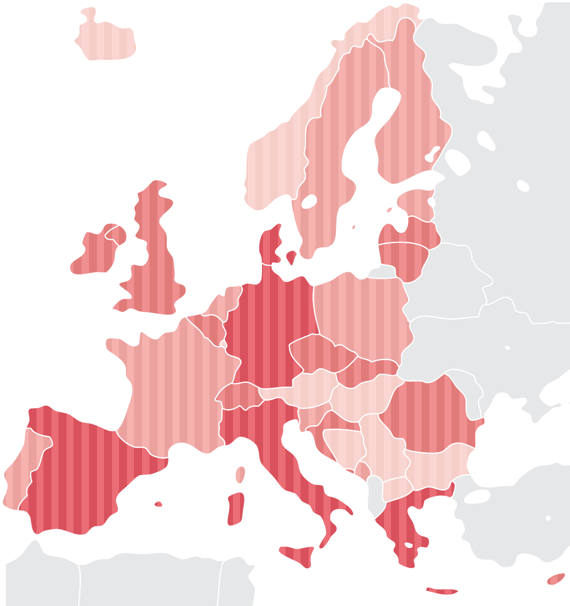
## Scenario Vision 1 and Vision 3

For Vision 1, Germany (67 %) and Denmark (64 %) are closely followed by Slovakia (61 %), as well as Cyprus, Spain and Italy (between 50 and 60 %).



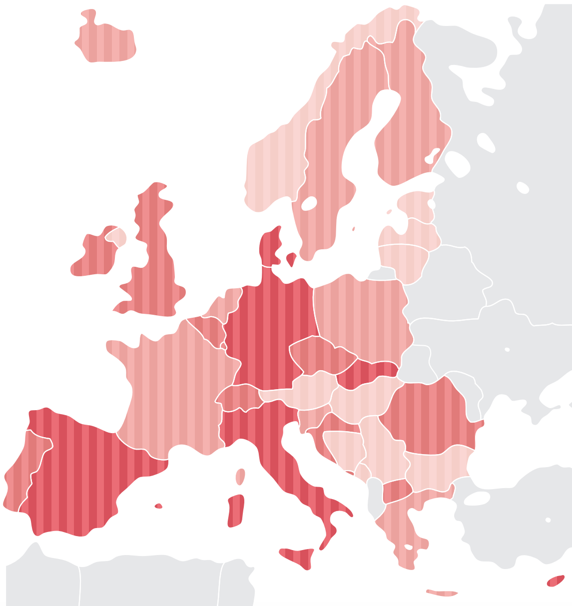
ENTSO-E average: 42% < 25 % ≥ 25 % & < 35 % ≥ 35 % & < 45 % ≥ 45 %

Figure 3.3.7:
UC as a part of NGC per country in 2020, Scenario B, January



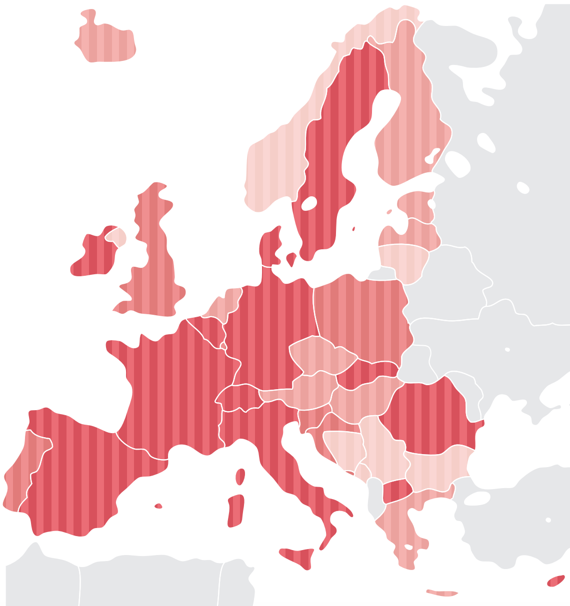
ENTSO-E average: 43% < 25 % ≥ 25 % & < 35 % ≥ 35 % & < 45 % ≥ 45 %

Figure 3.3.8:
UC as a part of NGC per country in 2020, Scenario EU 2020, January



ENTSO-E average: 44% < 25 % ≥ 25 % & < 35 % ≥ 35 % & < 45 % ≥ 45 %

Figure 3.3.9:
UC as a part of NGC per country in 2030, Vision 1, January



ENTSO-E average: 48% < 25 % ≥ 25 % & < 35 % ≥ 35 % & < 45 % ≥ 45 %

Figure 3.3.10:
UC as a part of NGC per country in 2030, Vision 3, January

As Vision 3 assumes the largest RES penetration levels, it is not surprising that it yields the highest UC ratios by far, reaching as high as 78 % in Denmark. Germany follows with a value of 68 %, while Slovakia, Spain, Italy and Sweden also have unavailable capacities exceeding half of the Net Generation Capacity.

# 4 ADEQUACY FORECAST

# 4.1 ENTSO-E Adequacy Forecast

## Remaining Capacity & Adequacy Reference Margin

### Scenario A and Scenario B

Remaining Capacity (RC) shows different trends in Scenario A and Scenario B according to the different assumptions made for each of them. The expected Remaining Capacity (RC) values for the whole forecast period are presented in Table 4.1.1 and Figure 4.1.1

| [GW] | Scenario | 2013 | 2015 | 2016 | 2020 |
|---|---|---|---|---|---|
| January 7 p.m. | A | 111 | 113 | 102 | 79 |
| | B | 111 | 118 | 116 | 124 |
| July 11 a.m | A | 197 | 202 | 188 | 171 |
| | B | 196 | 208 | 200 | 218 |

Table 4.1.1:
ENTSO-E RC for Scenarios A&B

RC at an ENTSO-E level is expected to be positive for both Scenarios at both reference points during the entire forecast period. However, the level of RC in Scenario A is lower in 2016 and 2020 than the one available in 2013. A decrease in RC can be observed between the years 2015 and 2016 for both Scenarios. For Scenario A, this decrease lasts until 2020, while in Scenario B, RC increase is visible after the year 2016. In Scenario A, 32 GW of firm generation capacity is missing in 2020, if the RC level of 2013 is judged as an adequate benchmark. Figures 4.1.2 and 4.1.3 show RC as a part of NGC per country in 2015 and 2020.

In the majority of ENTSO-E countries, the share of RC in the total NGC is higher than the average ENTSO-E value in 2015.

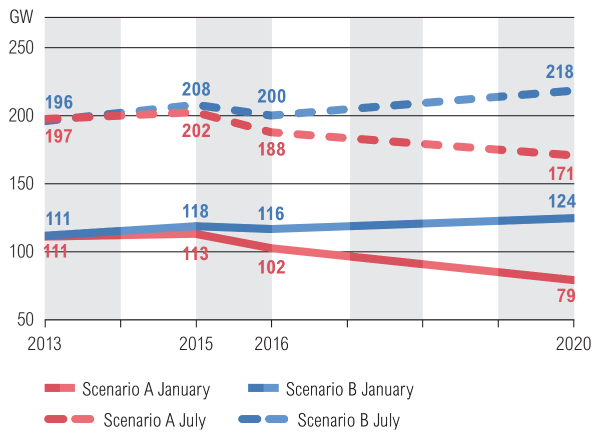



Figure 4.1.1:
ENTSO-E RC forecast, Scenarios A&B

The highest levels of RC as part of NGC in 2015 are in the Netherlands (36 %) and Luxemburg (35 %), followed by Bulgaria (34 %) and Austria (33 %). The only country foreseeing a slightly negative Remaining Capacity is Denmark (-0.4 %). In 2020, Austria (39 %), Bulgaria (36 %) and Bosnia-Herzegovina (35 %), followed by Estonia (32 %) and Luxemburg (31 %) expect the highest share of RC in NGC. On the other hand, Finland (-3 %), Denmark (-1 %) and Germany (-0.4 %) show the lowest values.

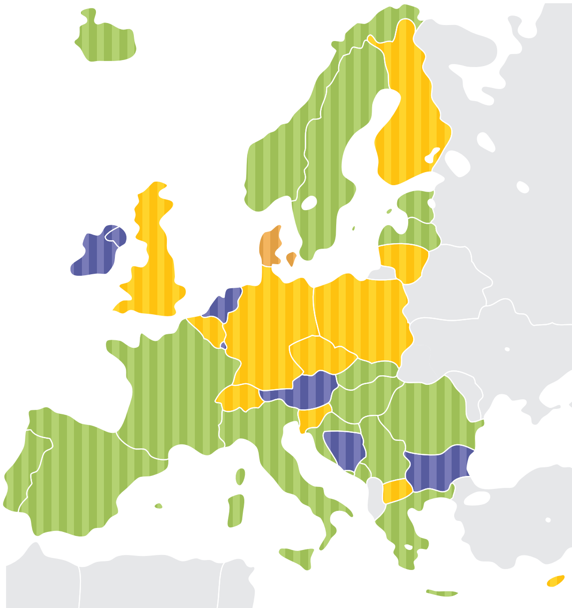



Figure 4.1.2:
RC as a part of NGC per country in January 2015, Scenario B

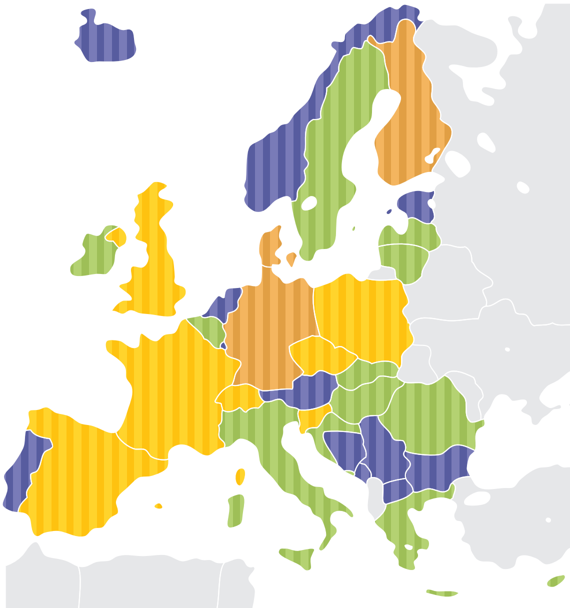



Figure 4.1.3:
RC as a part of NGC per country in January 2020, Scenario B

| | | [GW] | 2013 | 2015 | 2016 | 2020 |
|---|---|---|---|---|---|---|
| **January, 7 p.m.** | Scenario A | Margin against Peak Load | 30 | 30 | 30 | 31 |
| | | Spare Capacity | 50 | 52 | 52 | 55 |
| | | **ARM** | **79** | **82** | **83** | **86** |
| | | **RC - ARM** | **31** | **31** | **20** | **-7** |
| | Scenario B | Margin against Peak Load | 30 | 30 | 30 | 32 |
| | | Spare Capacity | 50 | 53 | 54 | 59 |
| | | **ARM** | **79** | **83** | **84** | **91** |
| | | **RC - ARM** | **32** | **35** | **32** | **33** |
| **July, 7 p.m.** | Scenario A | Margin against Peak Load | 34 | 35 | 35 | 36 |
| | | Spare Capacity | 50 | 52 | 53 | 55 |
| | | **ARM** | **84** | **87** | **88** | **91** |
| | | **RC - ARM** | **113** | **115** | **100** | **79** |
| | Scenario B | Margin against Peak Load | 34 | 35 | 35 | 36 |
| | | Spare Capacity | 50 | 53 | 54 | 60 |
| | | **ARM** | **84** | **88** | **89** | **96** |
| | | **RC - ARM** | **111** | **120** | **111** | **122** |

Table 4.1.2:
ENTSO-E RC and ARM comparison for Scenarios A&B

Table 4.1.2 shows the values of RC-ARM for Scenarios A and B for both reference points. The generation adequacy within the whole ENTSO-E system in Scenario B is expected to be maintained during the entire forecast period 2013 – 2020 in most of the situations. In Scenario A, generation adequacy is expected to remain stable until 2016 at the winter reference point (Figures 4.1.4 and 4.1.5). After this year, it seems necessary to install some new generating units in order to deal with unexpected load variations within the ENTSO-E system. Scenario B retains positive values during the whole period at both reference points.

The situation in each country is presented in Figures 4.1.6 and 4.1.7 below. In most countries, the difference between RC and ARM is positive.

In 2015, the countries with the highest share of RC-ARM in their national RAC are Luxemburg (36 %), Austria (33 %) and the Netherlands (31 %) followed by Bulgaria (30 %), Latvia (26 %) and Bosnia-Herzegovina (21 %). In 2020, Austria (42 %), Bulgaria (34 %) and Portugal (32 %) have the highest values.

The countries with the lowest share in 2015 are Cyprus (- 17 %) and Denmark (- 13 %), Switzerland and Montenegro (- 9 %), Lithuania (- 8 %), and Belgium (- 7 %), followed by Finland, Poland, Germany and Serbia with ratios of between -6 % and 0. In 2020, Denmark (-14 %) foresees the lowest rate, while Northern Ireland, Switzerland, Finland, Poland, Greece, Germany and Cyprus show a share between zero and -12 % each.

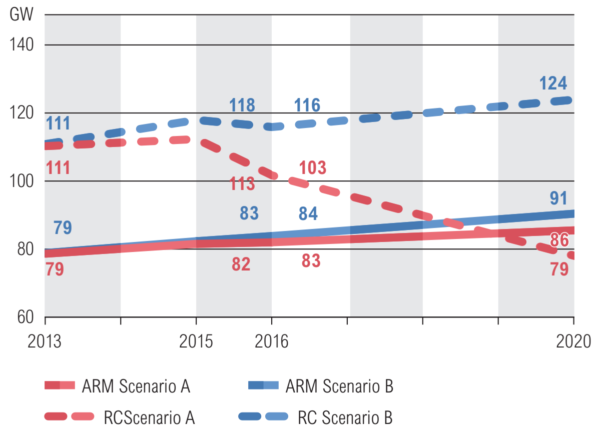



Figure 4.1.4:
ENTSO-E RC and ARM comparison, Scenarios A&B, January 7 p.m.

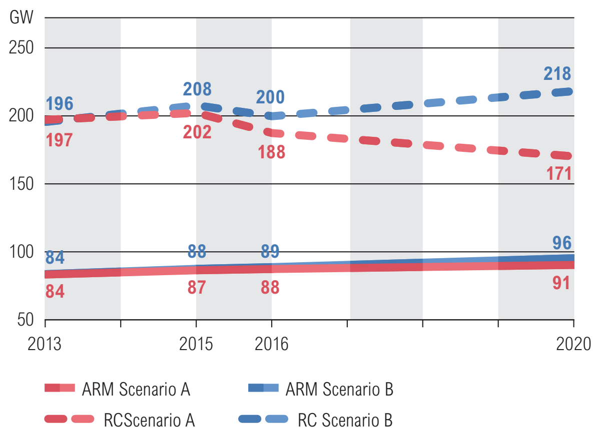



Figure 4.1.5:
ENTSO-E RC and ARM comparison, Scenarios A&B, July 11 a.m.

## Scenario EU 2020

RC as a part of NGC per country in 2020 is shown in Figure 4.1.8 below. In the majority of the countries, the share of RC in total NGC is higher than the average ENTSO-E value, remaining positive in all countries with the exception of Germany and Finland.

The highest levels of RC as part of NGC in 2020 are those of Luxemburg (51 %), Austria (42 %), Bulgaria (35 %) and Bosnia-Herzegovina (30 %); the lowest values are expected in Finland (-2.0 %), Germany (-0.4 %), as well as Denmark, Montenegro, Northern Ireland, Czech Republic, Great Britain and Poland (positive values below 5 %).

As for RC-ARM expressed as a percentage of Reliable Available Capacity, the highest value also corresponds to Luxemburg (51 %), followed by Austria (45 %) as well as Bulgaria, Portugal and Latvia. The lowest values occur in Montenegro (-17 %), Denmark (-14 %), Northern Ireland (-12 %), as well as Belgium, Finland, Germany and Poland (between -10 % and -5 %).

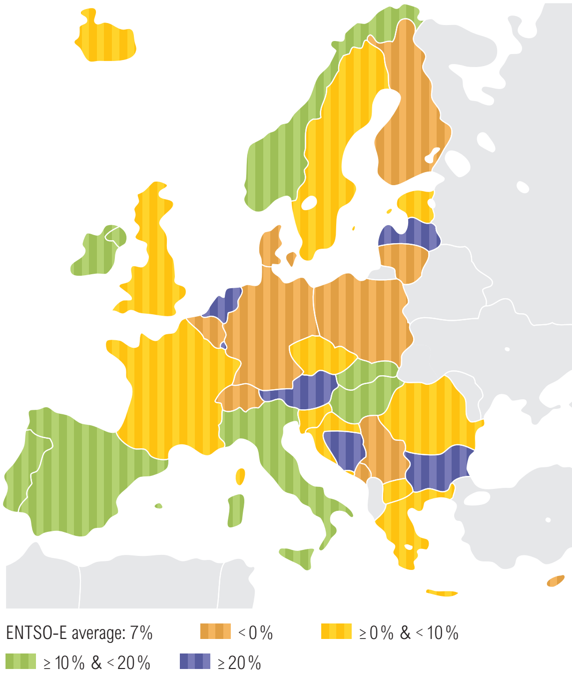



Figure 4.1.6:
Remaining Capacity minus Adequacy Reference Margin as a part of Reliably Available Capacity per country, Scenario B, January 2015, 7 p.m. *

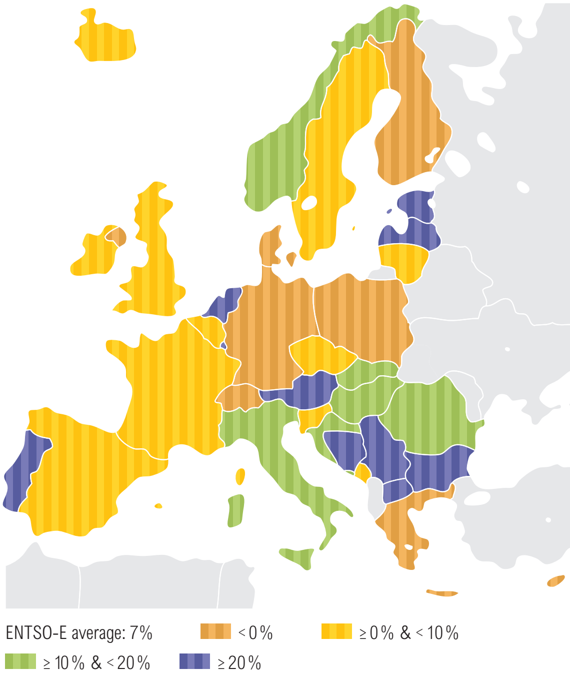



Figure 4.1.7:
Remaining Capacity minus Adequacy Reference Margin as a part of Reliably Available Capacity per country, Scenario B, January 2020, 7 p.m.

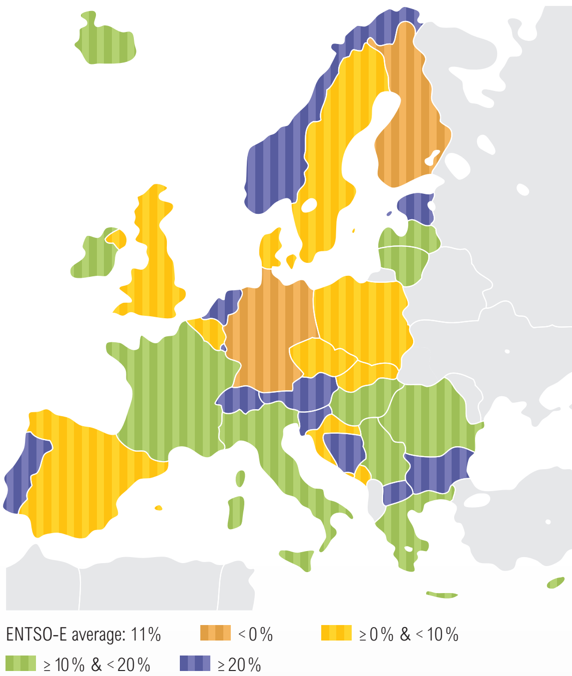



Figure 4.1.8:
RC as a part of NGC per country – Scenario EU 2020, reference point January

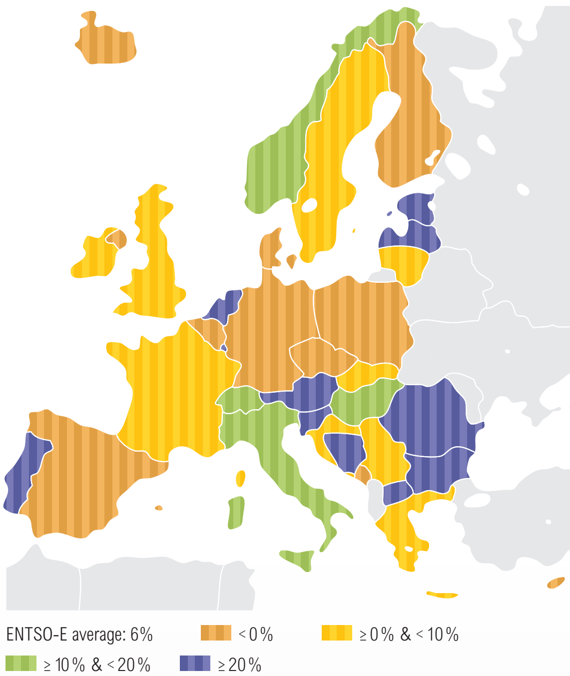



Figure 4.1.9:
Remaining Capacity minus Adequacy Reference Margin as a part of Reliably Available Capacity per country, Scenario EU 2020, reference point January

* The Adequacy Reference Margin includes Margin Against Seasonal Peak Load. As seasonal peak load does not occur simultaneously, this map shall not be understood as a European-level assessment of adequacy.

# 4.2 Regional Analysis

## Remaining Capacity Minus Spare Capacity

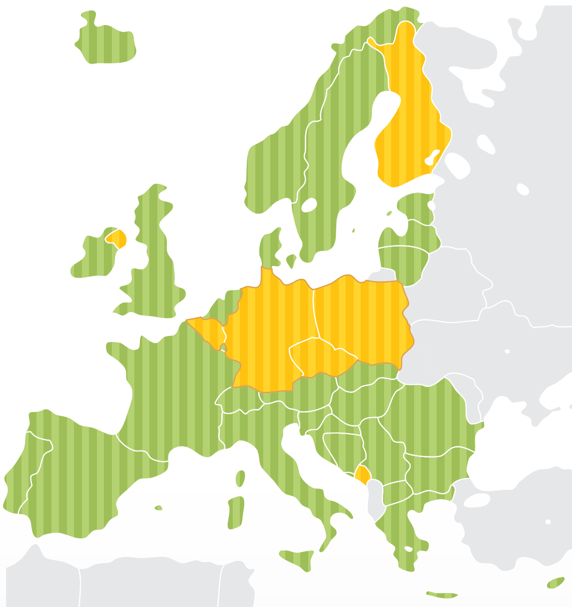
### Scenario EU 2020

According to the results, the block of Belgium, Germany, Czech Republic and Poland may simultaneously require import in the winter period under the assumptions of the Scenario EU 2020. Import from all countries directly connected to this group is foreseen, with Germany possibly requiring the most import. The total of the RC-SC in the four countries is -6.9 GW, whilst there is ample (approximately 26 GW) import capacity available on the external borders of the group to cover this amount.

No other significant regions or groups of countries are identified as requiring simultaneous imports.

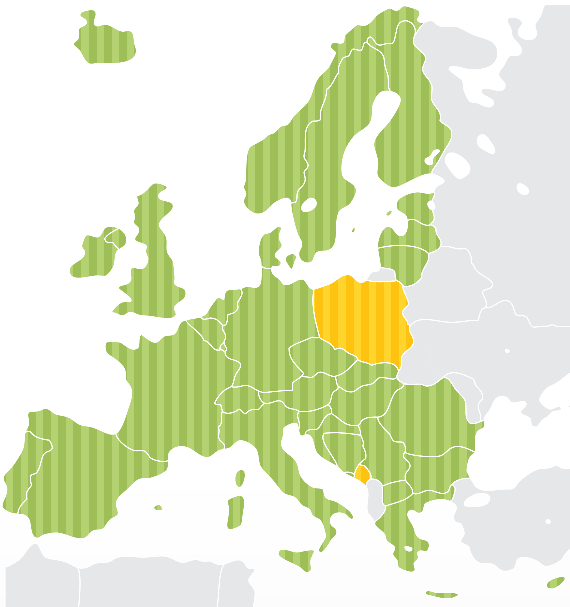
The RC-SC value in Poland for the July reference point is -1.96 GW, while the simultaneous import capacity amounts to 3.82 GW. Approximately half of the import capacity may be necessary, thus reducing transit flow possibilities in the region.

No other significant country or group of countries are identified as requiring simultaneous imports.



NO IMPORTS REQUIRED to cover demand and reserves
IMPORT REQUIRED required import <= simultaneous import capacity
IMPORT REQUIRED required import > simultaneous import capacity

Figure 4.2.1:
Regional analysis – January reference point



NO IMPORTS REQUIRED to cover demand and reserves
IMPORT REQUIRED required import <= simultaneous import capacity
IMPORT REQUIRED required import > simultaneous import capacity

Figure 4.2.2:
Regional analysis – July reference point

# 5 CONCLUSIONS

The SO&AF 2013 is prepared based on input data provided by TSOs (national data correspondents) from ENTSO-E member countries during September and October 2012, with modifications until the middle of December 2012. It covers the time period from 2013 to 2030 (depending on the Scenario).

Assessment and evaluations have been prepared for three Scenarios until 2020, as well as two Visions for 2030:

- Scenario EU 2020 (based on NREAPs),
- Scenario A ("Conservative Scenario") and
- Scenario B ("Best Estimate Scenario"); as well as
- Vision 1 "Slow progress" and
- Vision 3 "Green transition".

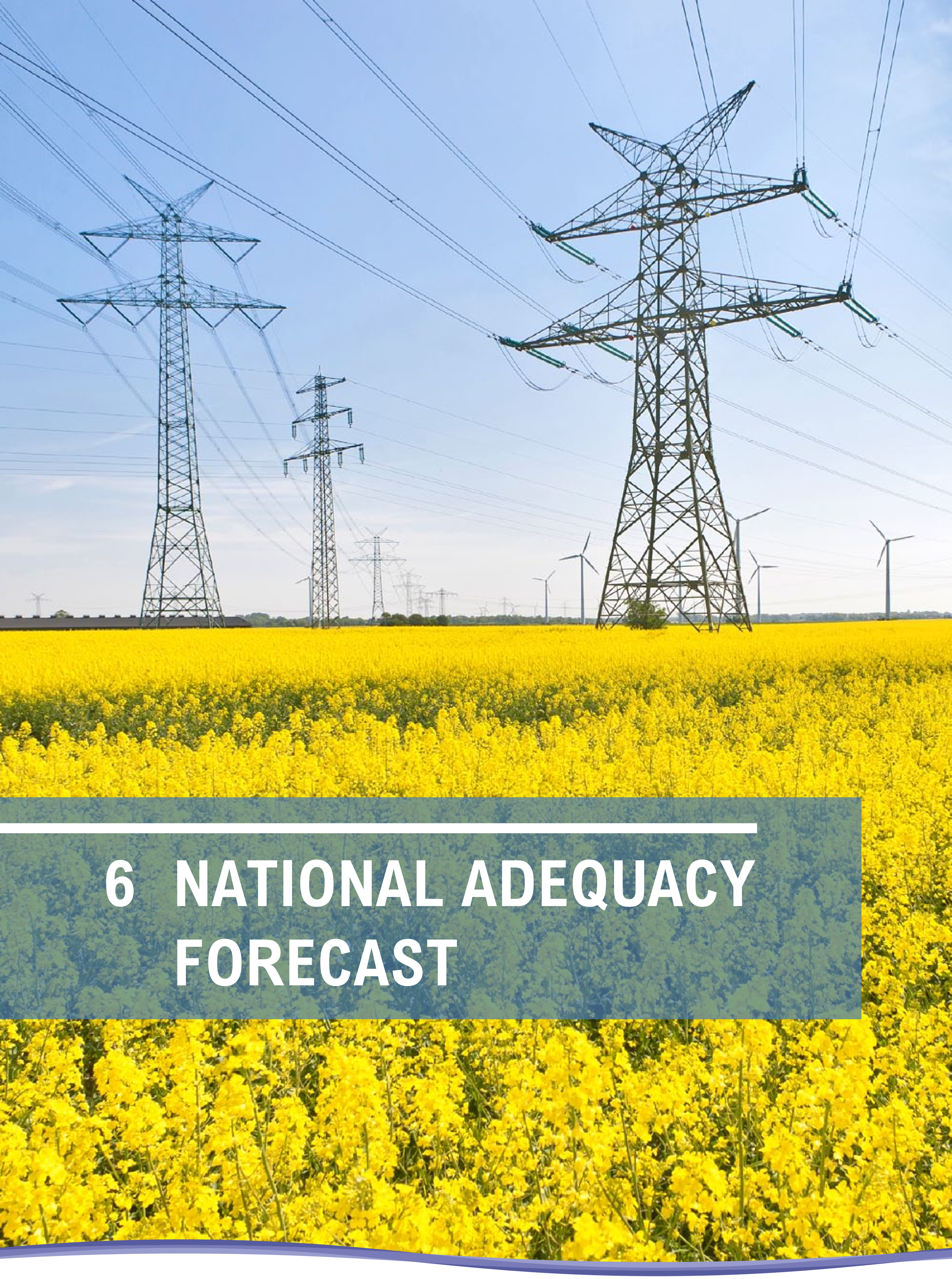
Details and underlying assumptions of the different Scenarios can be found in the Methodology section of the report.

Load is expected to increase throughout the entire forecast period in each scenario. The best estimate of TSOs foresees an approximate annual average growth of 1% between 2013 and 2020, reaching a slightly higher load value in 2020 than that corresponding to the EU 20-20-20 policy goals. The different assumptions for 2030 Visions result in a possible annual growth rate in the next decade ranging from 0% to 1%. For the entire ENTSO-E area, the expected total load growth in Scenario B until 2020 is approximately 40 GW, compared to the 2013 expected values. Cyprus and Slovenia expect the fastest load increase.

The total ENTSO-E Net Generating Capacity (NGC) is also increasing in each scenario. Of all primary energy sources, the biggest development is reported for renewable energy sources (including renewable hydro generation). The foreseen increase in RES capacity (regardless of the Scenario) could be expected, and is a confirmation of continuous investor interest, also promoted by the existing support schemes on a national or European level. Wind and solar generation are the main drivers of the expected RES installed capacity growth, and within wind, offshore installations may increase their share in the 2020s. The total growth of RES capacity between 2013 and 2020 in Scenario B is 170 GW, which corresponds to a 50% increase (out of which 95 GW is wind, 53 GW is solar, 12 GW is biomass, and 10 GW is hydro).

The fastest developing capacities within fossil fuels are gas power units in each scenario. This increase is continuous over the assessed period, regardless of the Scenario (except Scenario A after 2015). Cyprus has the highest ratio of installed capacity of gas power units as a part of NGC in both Scenarios, followed by the Netherlands and Hungary. Lignite, hard coal and oil power plant capacities are decreasing in each scenario.

The report also notes that the generation adequacy is expected to be maintained during the entire forecast period until 2020 (in Scenario B and Scenario EU20, and in each reference point), even after the expected shut down of German (and also Swiss and Belgian) nuclear power plants after the Fukushima accident. It must be noted however, that under Scenario A, at the reference point January 2020, the level of adequacy becomes slightly negative, underlining the need for further investments compared to what is confirmed today. When these results are compared to those of the previous SO&AF 2012, no deterioration is observed.



# 6 NATIONAL ADEQUACY FORECAST

This section consists of a graph comparing Import/Export capacity to the difference between Remaining Capacity and the Adequacy Reference Margin in Scenarios A, B and EU 2020 for each ENTSO-E member or corresponding member. When Export/Import capacity differs significantly between Scenarios, a separate graph for each respective Scenario is inserted.

The text part of this chapter consists of comments provided by each national data correspondent during the data collection process. If the country does not provide any data at all, it is not mentioned in this chapter. As not every ENTSO-E country is obliged to set its national environmental goals according to the EU 3rd energy package, a number of countries do not have their own NREAP or Scenario EU 2020 (or their Scenario EU 2020 is based on a document similar to NREAP). Therefore, if nothing to the contrary is stated in the national comments, these paragraphs are valid for each Scenario (A, B and EU 2020).

Data displayed in the graphs refer to the January, 7 p.m. reference point.

## 6.1 AT – Austria

### Generating Capacity

Calculations for Scenario B (and partly for Scenario EU 2020) are based on data collected from market participants for the "Masterplan 2030" (APG 2013). Some plans for fossil fuel power plants (mostly CCGT power plants) are postponed or even cancelled. In addition some pump storage power plants are also postponed. Due to a new legislative framework for renewables, a sharp increase in wind and solar power plants is expected.

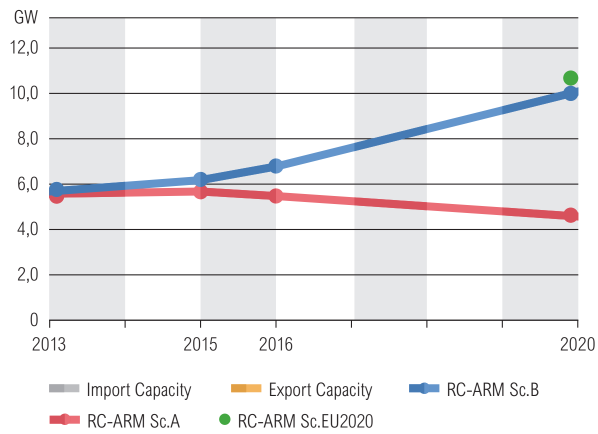



Figure 6.1:
RC-ARM Comparison Austria,
Scenarios A, B and EU 2020, January 7 p.m.

### Unavailable Capacity

100 % of wind and solar power plants are treated as unavailable capacity. For hydro power plants, historical data concerning unavailability are extrapolated.

### Load

The forecast of load in Scenarios A and B is based on the load forecast for the reference scenario of the NREAP 2010. For Scenario EU 2020 the efficency scenario of NREAP 2010 is taken into account.

### Generation Adequacy

For all Scenarios sufficient RC-ARM is available in the Austrian electricity system.

### Interconnection Capacity

No problems concerning transmission capacity are expected if the grid projects described in the "Austrian Network Development Plan 2012" and in the "Masterplan 2030" are carried out. Specific Import/Export capacity values are not given due to the assumption that no significant limitation exists on the German border.

## 6.2 BA – Bosnia & Herzegovina

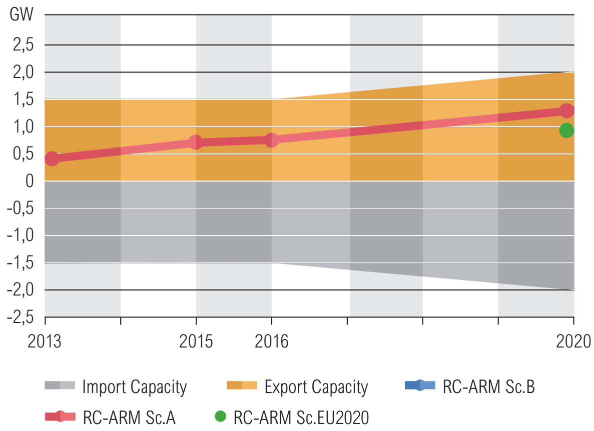



Figure 6.2:
RC - ARM Comparison Bosnia & Herzegovina,
Scenarios A, B and EU 2020, January 7 p.m.

## 6.3 BE – Belgium

The Belgian figures refer to Belgian territory and reflect the Belgian national figures (including all voltage levels in Belgium). Furthermore, the reference point for the load figures is based on real measurements which are supplemented by estimates to ensure 100 % representativeness.

### Generating Capacity

The renewable generation in all Scenarios in 2020 respects the renewable energy level in TWh announced in the Belgian NREAP, but deviates from the installed capacities. The deviation results from taking into account regional objectives regarding the installed generation capacity of wind, renewable hydro and solar, as well as the current installed generation capacities.

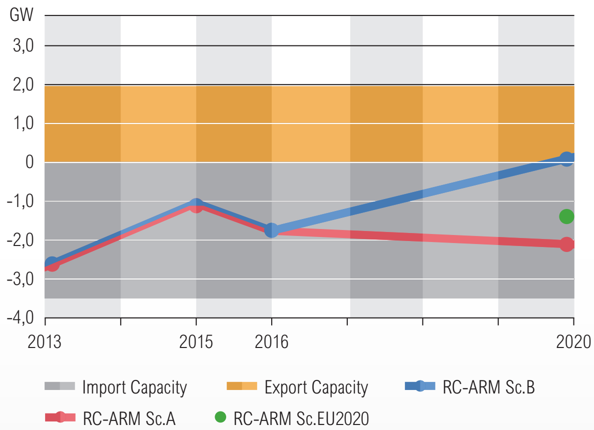



Figure 6.3:
RC - ARM Comparison Belgium,
Scenarios A, B and EU 2020, January 7 p.m.

The RES installed capacities in Vision 1 (year 2030) are – as requested by ENTSO-E methodology – are the same as those used for Scenario EU 2020 in the year 2020. The RES installed capacities in Vision 3 (year 2030) are constructed by prolongation of the growth rate between 2020 and 2019 until 2030 for onshore wind farms, biomass plants and photovoltaic panels. The installed capacity of offshore wind is set at the maximum offshore capacity taken into consideration in the NSCOGI offshore grid study for Belgium for 2030. For run-of-river generation it is assumed that the maximum potential has already been obtained in 2020.

The evolution of the thermal capacity depends on the Scenario.

For all Scenarios it is assumed that the two nuclear plants (approx. 2000 MW) which have been taken out of service due to cracks in the reactor vessels, will not be available over the winter of 2012/13, but will probably return to service after the winter. If this assumption is not correct, the generation adequacy situation will be more stressed for the period 2013 – 2016. The implementation of the nuclear phase-out is taken into consideration in all Scenarios, including the revision which has been decided on by the federal Belgian government on 4th of July 2012 postponing the phase out of one unit by 10 years (1 GW).

It is assumed in all Scenarios that no new thermal units will be commissioned and that no existing thermal units will be decommissioned in the horizon 2013 – 2016. Following 2016, thermal units are decommissioned, taking into account a maximum technical lifetime of 45 years. The units are commissioned based on the assumption that generation adequacy at normalised peak load should be maintained. The commissioned thermal units are assumed to be gas power plants.

### Unavailable Capacity

Unavailable capacity will increase over the period 2013 – 2030, mainly due to a rise in the number of wind farms, biomass power plants, photovoltaic panels and CHPs included in the net generating capacity, for which the average unavailability is considered. This trend will lead to an increase in the volume of non-usable capacity.

### Load

The proposed ENTSO-E load methodology is applied.

Elia has numerous load-shedding contracts with industrial customers. These contracts are part of the system services reserve and increase from a contracted volume of 261 MW in 2013 to 300 MW in 2015. No estimation of the system services needed in 2030 is available, meaning that the level is assumed to remain the same in 2030 as in 2020.

The reported energy level in Scenario EU 2020 for the year 2020 is lower than the level reported in the TYNDP 2012 report due to the fact that the load forecast in the Belgian NREAP has been established prior to the financial and economic crisis. The current official energy forecast is much lower, although no update of the Belgian NREAP has been submitted by the Belgian government to the European Transparency platform. The entered data reflect an observed lower starting point for demand projections caused by economic downturn as well as lower official energy growth rates.

## Generation Adequacy

A statistical study performed by Elia identifies elevated risks for the Belgian grid: assuming that both nuclear power plants with cracks in the reactor vessel are not available during the winter 2012/13, system adequacy could only be fulfilled under the following prerequisites:

- Cancel the recent planned permanent shutdown of approx. 1000 MW of old thermal plants;
- Have 3,500 MW interconnection capacity available for imports into the Belgian grid (supposing that excess generation is available in other Central Western European countries);
- Average temperatures for the coming winter and limited growth of the peak loads.

In case one of these prerequisites is not fulfilled – for instance if there is a cold spell similar to the one experienced in February 2012 – additional demand limiting actions will probably have to be taken. An intermediate assessment of the period November 2012 – January 2013 reveals that Belgium is structurally dependent on import from neighbouring countries over this period, although no additional actions are needed due to a high availability of generation capacity, as well as a low demand in France. All efforts aiming to raise awareness of Central Western European market players and neighbouring TSOs has paid off with a maximum availability of generation and grid in the CWE region in this period. However, the maintenance of generation and grid infrastructure cannot be delayed endlessly. These types of measures can only temporarily balance generation adequacy problems.

The spare capacity is elaborated on using the proposed ENTSO-E methodology for an individual country. It is set at 5 % of Net Generating Capacity. However, since the non-usable capacity of wind is determined using the average historical output profile of wind during January, an additional capacity is taken into account reflecting the difference between this average availability and availability of only 10 % for the installed wind capacity.

The normalised winter and summer peak load is obtained by aggregating the forecasts of the TSO of individual loads at the different nodes of the transmission grid for the different years.

The margin against peak load does not reflect a peak load which occurs under severe temperature conditions.

### Interconnection Capacity

The simultaneous import and export capacity is the assessed average simultaneous import and export capacity for the winter 2012/13. Future possible interconnection reinforcements which remain under study (such as new interconnections between Belgium and Luxemburg, between Belgium and Germany and between Belgium and the UK), are not considered in the current assessment reported in the SO&AF of the simultaneous Import/Export capacity.

## 6.4 BG – Bulgaria

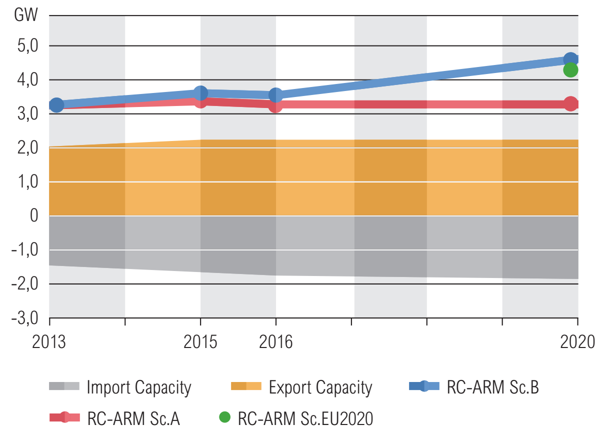



Figure 6.4:
RC-ARM Comparison Bulgaria,
Scenarios A, B and EU 2020, January 7 p.m.

## 6.5 CH – Switzerland

### Generating Capacity

For Switzerland, Scenarios A and B are the same. For Scenario EU 2020, total hydro power capacity is significantly higher.

### Unavailable Capacity

Unavailable Capacity is calculated on the basis of coefficients for winter and summer seasons. The coefficients reflect the availability of all power plants. The largest differences are observed for hydro power plants.

### Load

The load forecasts in Scenarios A and B are based on a reference load increase. Due to energy efficiency measures, the load in Scenario EU 2020 is lower.

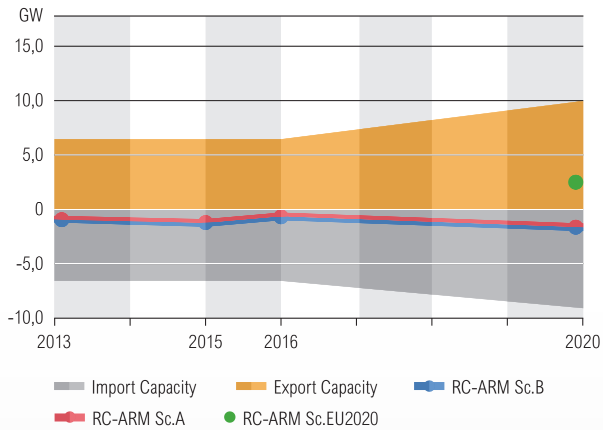



Figure 6.5:
RC-ARM Comparison Switzerland,
Scenarios A, B and EU 2020, January 7 p.m.

### Generation Adequacy

Scenario A and B are identical. Scenario EU 2020, total hydro power capacity is significantly higher.

### Interconnection Capacity

Simultaneous Import / Export capacity in 2020 is identical for Scenarios A, B and EU 2020. It reflects the strategic grid 2020.

## 6.6 CY – Cyprus

### Generating Capacity

After the devastating accident in July 2011 near the main power plant Vasilikos, restoration works have progressed significantly, both in terms of building works and in terms of Generating Unit repair and commissioning:

Two Combined Cycle Generating Units with a total capacity of 440 MW have already been recommissioned and will soon be commercially available. In addition, a 37 MW Open Cycle Gas Turbine has been repaired and is operating. The restoration works on the remaining three Steam Turbine Units, with a total capacity of 390 MW will start soon.

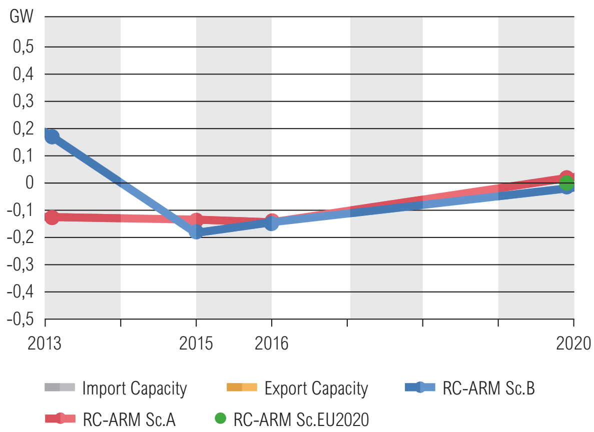



Figure 6.6:
RC - ARM Comparison Cyprus,
Scenarios A, B and EU 2020, January 7 p.m.

### Unavailable Capacity

In the isolated system of Cyprus NGC renewables, particularly wind power, are not considered as a part of the calculations for the Reliable Available Capacity.

## 6.7 CZ – Czech Republic

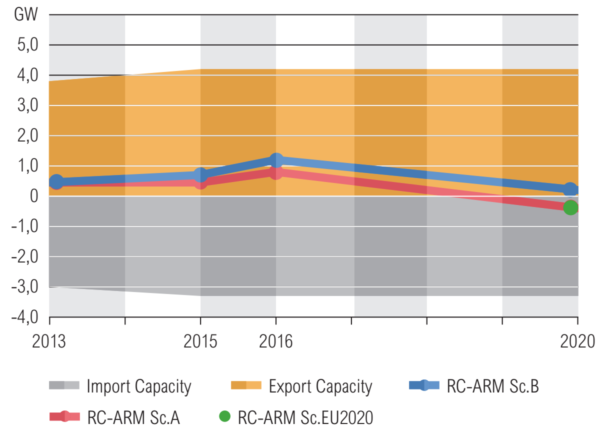



Figure 6.7:
RC - ARM Comparison Czech Republic,
Scenarios A, B and EU 2020, January 7 p.m.

## 6.8 DE – Germany

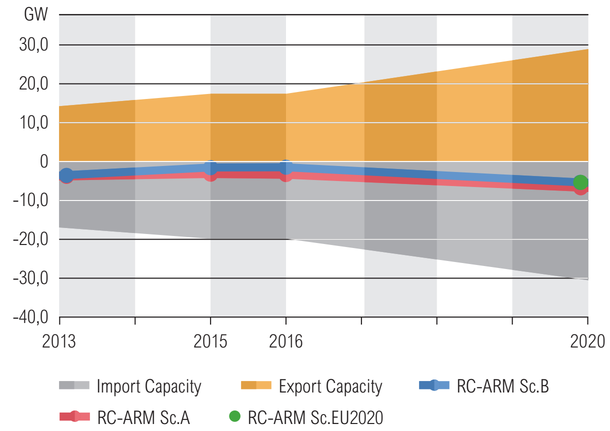



Figure 6.8:
RC - ARM Comparison Germany,
Scenarios A, B and EU 2020, January 7 p.m.

## 6.9 DK – Denmark

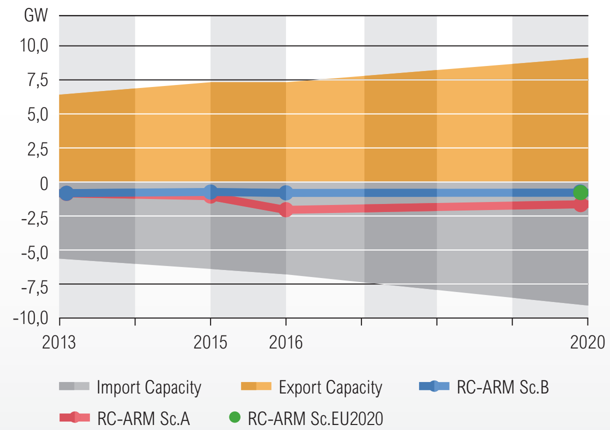



Figure 6.9:
RC - ARM Comparison Denmark,
Scenarios A, B and EU 2020, January 7 p.m.

## 6.10 EE – Estonia

### Generating Capacity

At present the power system of Estonia has 2.6 GW of generation capacity installed, with this capacity sufficient to cover peak loads according to both Scenarios A and B. Currently, electricity production is mainly based on oil shale and the remaining share is covered by biomass fuel and wind power in Estonia.

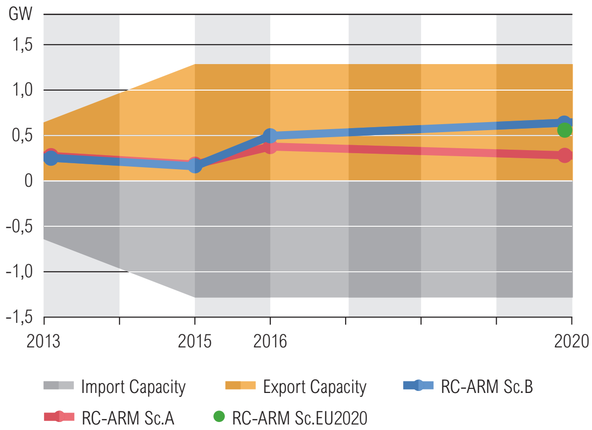



Figure 6.10:
RC - ARM Comparison Estonia,
Scenarios A, B and EU 2020, January 7 p.m.

Starting in 2016, when the emission limitations of existing oil shale units will enter into force, these power units, contributing significantly to available capacity, will not meet the requirements of the EU directive of large combustion plants. However, the Industrial Emissions Directive (IED) means that it is possible to use an additional 0.64 GW capacity during the period spanning 1 January 2016 to 31 December 2023. Due to this, the Estonian demand will be covered in both A and B Scenarios by domestic production, considering the expected demand increase during winter time.

As of today, 0.27 GW of wind parks have been connected to the Estonian national grid, whilst there are also a number of new wind parks planned and under construction. Within the period 2013 – 2020, we do not take into account these wind park projects, the construction of which we do not have details. The total amount of wind energy in use and under construction in Scenario A is 0.3 GW.

According to Estonian legislation, power plants with efficient technology of heat and power cogeneration as well as power plants which produce electricity from renewable sources are eligible for subsidies. Based on this assumption, an increase in the construction of new CHP and wind parks can be expected. Up to 0.2 GW of new wind parks and CHP plants based on different fuels (peat and biomass) are taken into account in Scenario B.

The information for the EU 2020 Scenario has been agreed with the Renewable Energy Department of the Ministry of Economy and Communications. Energy demand forecast is also provided by the Ministry of Economy and Communications. Generating capacity for Scenario EU 2020 is for the most part (fossil, mix fuels, hydro), based on Scenario A, with the main difference pertaining to wind and biomass generation capacity.

### Unavailable Capacity

By non-usable capacity we mean mothballed units, all kinds of limitations and all installed wind power in all Scenarios. The power units which have NGC of approximately 0.3 GW will be mothballed due to emission limitations starting from 2015. It is assumed that around 50 % of CHP power would be unavailable due to maintenance and technological limitations during the summer period. According to hydrological conditions (water inflow), it is assumed that the available capacity of hydro power plants would be around 50 % of their net generating capacity.

### Load

The electricity demand forecast is based on the respective forecast in the main branches of the economy as well as on GDP growth rate projections of GDP growth rates. The main factors influencing energy demand are changes in the GDP. According to the average weather conditions, growth during this period is expected to be around 2.4 % annually.

### Generation Adequacy

With regards to Scenario A, the situation will worsen from 2016 but due to IED directive mitigation the adequacy would be met within the winter periods during 2016 – 2020.

According to Scenario B, the remaining capacity would be met with a surplus during the whole period in case of fast and expected demand growth.

### Interconnection Capacity

The most important investments from the security of supply point of view from Elering will be the implementation of a second interconnection between Finland and Estonia with a capacity of 0.65 GW and the construction of the new power plant of 0.25 GW for emergency reserve. These projects will be finished by the end of 2014 and 2015, respectively.

Interconnection capacity is expected to increase by approximately 0.5 GW with a new connection between Estonia and Latvia after 2020, although there is no final decision on this project as of today.

## 6.11 ES – Spain

### Load

Over the last years, demand has ceased to increase. The demand in 2012 is below the 2006 level, whilst a significant increase is not foreseen in the short term. In the long term, energy demand is expected to grow at average values slightly below 2 % (y/y), while peak demand is expected to reach 53 TW in January 2020 under severe conditions, in the best estimate scenario.

The demand coverage studies are based on the demand forecast studies carried out by Red Eléctrica. From these studies, values for annual energy and annual peak demand are forecast; values which will define the evolving needs of the generating equipment to meet this demand and to maintain the security and quality of electricity supply.

## Generating Capacity

### Best Estimate Scenario – 2020

Despite the recent regulatory changes regarding RES, the evolution of installed generation capacity in the Spanish peninsular electricity system up to 2020 is expected to be driven mainly by RES power, particularly solar and onshore wind. Overall, net generating capacity will be roughly 10% higher in 2020 than today; that is, capacity will still increase, but at a slower rate than demand.

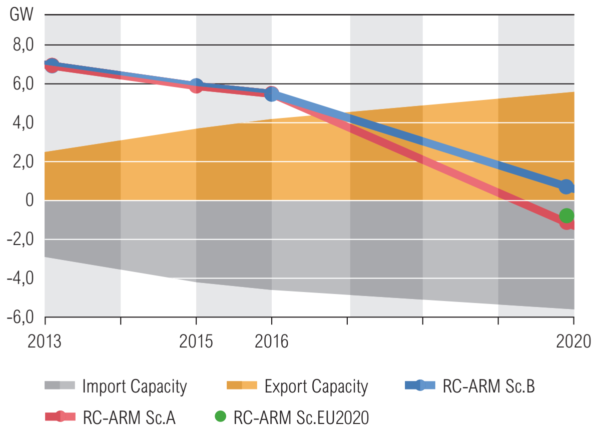



Figure 6.11:
RC-ARM Comparison Spain,
Scenarios A, B and EU 2020, January 7 p.m.

### 2030 Visions

In Vision 3, the installed wind power is expected to reach 48 GW, including some offshore facilities. Solar energy (both PV and CSP) is also expected to grow, up to 24 GW in 2030. Along with the expansion of RES, backup technologies such as pumping and peak units will also increase. In terms of hydro generation, new pumping units are expected which will add a capacity of 3.4 GW when compared to 2020. These projects, along with the development of new interconnections, are of key importance when it comes to effectively integrating the expected renewable power in the electrical system. Indeed, this is a strategic objective for the System Operator and is in line with the energy policy objectives set by the European Commission.

## Generation Adequacy

In the medium term (2013 – 2020), RC-ARM is positive for the entire period, and hence fulfils the adequacy criterion. However, adequacy will be highly dependent on the effective commissioning of the required additional power and also on weather conditions (mainly wind and hydro). Moreover, the margin is expected to decrease, meaning that the system could be at risk of suffering shortages after 2020 if the necessary investments do not take place.

For the year 2030, studies show that new generation capacity will be needed in order to maintain the security of supply. Depending on the Scenario (Vision) and the selected technology, some 30 to 50 GW of new installed capacity will be needed during the period 2020 – 2030, whilst well-designed market mechanisms are also of utmost importance if this level of investment is to be reached.

It is worth mentioning that beyond 2020, political decisions regarding the lifespan extension of 7 GW of nuclear units will be very relevant in terms of adequacy.

## Methodology

The methodology is described in the SO&AF document. With regards the calculation of non-usable capacity, these are the most important assumptions taken into account:

– Thermal forced outage rate: available thermal capacity with average probability of 95 % has been considered;

– Dry hydro conditions: significant non usable hydro capacity resulting from lack of water in the reservoirs;

– Wind conditions: available wind production exceeded with a probability of 90 % has been considered;

– Solar PV power is considered unavailable in the winter peak. Solar CSP is considered partly available thanks to the contribution of heat storage in tanks of melted salt and the possibility of back-up with fuel.

## Interconnection Capacity

The Iberian Peninsula has a very low interconnection exchange capacity with France, which is currently below 3 % with respect to peak demand. Nevertheless, the new interconnection line to France through the Eastern Pyrenees, the commissioning of which is projected for 2014, will allow for the doubling of the NTC between the two countries (and hence with the rest of ENTSO-E system). In the longer term, a new interconnection with France through the Bay of Biscay is under study and looks set to be commissioned around the 2020 horizon; it will raise the level of interconnection up to more than 4 GW, which would still be below the 10 % minimum recommended by the European Union.

Furthermore, the benefits of the development of the Spain-France interconnections include the improvement of the quality and safety of supply, the growth of energy trade volume between the Iberian Peninsula and the rest of ENTSO-E, as well as allowing for a greater and more efficient integration of renewable energy into the Iberian peninsular system.

The increase of transmission capacity not only to France but also to Portugal, with in the framework of the Iberian electricity market, is of great importance and one of the main concerns of Spanish TSO in terms of system adequacy and operational issues. Two new Spain-Portugal interconnections are expected to be commissioned by 2016, which will raise the bilateral NTC between Portugal and Spain to 3 GW.

## 6.12 FI – Finland

### Generating Capacity

The Government's aim is that the nation's own capacity should be able to provide for peak consumption and possible import disturbances. In Scenarios B and EU 2020 the renewable generation capacity is based on the National Renewable Energy Action Plan (NREAP) provided to the Commission in June 2010.

One nuclear unit is under construction and commercial operation is expected to commence at the beginning of 2015. The Finnish Government has approved the plans whilst the Parliament has ratified decisions-in-principle regarding two new nuclear power units. These plants are not expected to be commissioned until 2020. The capacity of combined heat and power plants is assumed to remain at the existing level. Some more renewable fuels will be used instead of fossil fuels both in the existing plants as well as in new plants; parts of which replace existing old units. The amount of necessary fossil capacity is based on the TSO's estimate, taking into account the above mentioned aim.

It is assumed that certain very old plants will be closed and replaced with plants using renewable fuels. Regardless, some new fossil units are needed to meet the above mentioned national aim. Because of higher demand in Scenario EU 2020 compared to Scenario B, similar renewable capacity and national policy, the need for fossil capacity is higher in Scenario EU 2020 than in Scenario B. Many power plants use several different fuels. Hence, power plants are classified according to their main fuel. Mixed fuels means peat. Biomass in most cases denotes black liquor or wood in different forms. Waste is included in the 'non-identifiable' capacity.

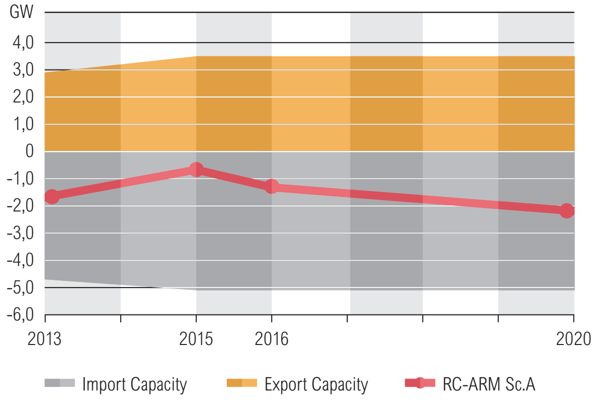



Figure 6.12.1:
RC-ARM Comparison Finland,
Scenario A, January 7 p.m.

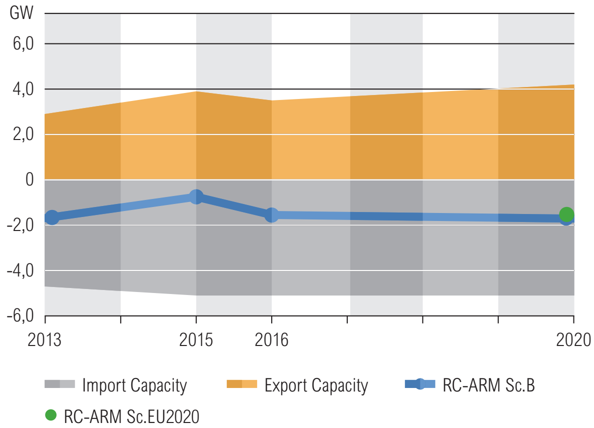



Figure 6.12.2:
RC-ARM Comparison Finland,
Scenario B and EU 2020, January 7 p.m.

### Unavailable Capacity

The amount of unavailable capacity is based on the TSO's estimate. It is not divided into different categories, with the exception of the System Service Reserve. Maintenance and overhauls of major plants are carried out during the summer. Electricity generation in combined heat and power plants for district heating is remarkably limited during the summer due to lack of heat load, etc. These reasons mainly explain the big difference between summer and winter. The availability of wind power is assumed to be small during the reference and peak hours.

### Load

Load forecast used in Scenario EU 2020 is estimated based on the Ministry's latest demand forecast included in the NREAP. At present the Ministry is preparing an updated Energy Policy including demand forecast. Load forecast in Scenarios A and B is the TSO's forecast and is prepared during autumn 2012; this is approximately 6 % lower than Ministry's forecast for 2020. Load at reference points corresponds to average temperature conditions. Some demand response is included in winter peak load, i.e. it is considered in Margin Against Seasonal Peak.

### Generation Adequacy

In all Scenarios the Remaining Capacity in winter remains negative for the entire period, except for immediately after the commissioning of the nuclear unit under construction. The consumption in Finland is strongly temperature dependent meaning that even in cold conditions the Remaining Capacity is negative. During summer reference day, the Remaining Capacity is positive in all Scenarios.

Spare capacity has not been defined in Finland. Hence Adequacy Reference Margin equals Margin Against Peak Load. In winter, this takes the impact of cold weather into account, although some demand response is assumed. The wide Margin Against Seasonal Peak Load in summer is explained by the fact that the load is at its lowest at the time of the reference day, while the load remarkably increases by the end of the season, i.e. end of September. Reliably, available capacity is at its lowest in June-July. Hence, RC-ARM in summer gives a pessimistic impression.

### Interconnection Capacity

A new interconnection to Estonia is under construction, and is set to be completed by the end of 2013. On the other hand, commissioning the new nuclear unit in 2015 will reduce import capacity from Sweden due to operational reasons. Changing the existing interconnection with Russia for two-way trade is under preparation. For the time being, commercial flow is only possible from Russia to Finland. This change is taken into account in Scenarios B and EU 2020.

## 6.13 FR – France

The following general comments have been provided regarding **Scenario B**:

Security of supply should be guaranteed through 2015, with the commissioning of several combined-cycle gas turbine plants offsetting the retirement of fossil-fired capacity over this timeframe.

More information is available in the 2012 update of the French generation adequacy report:

http://www.rte-france.com/uploads/Mediatheque_docs/vie_systeme/annuelles/bilan_preVisionnel/an/generation_adequacy_report_2012.pdf

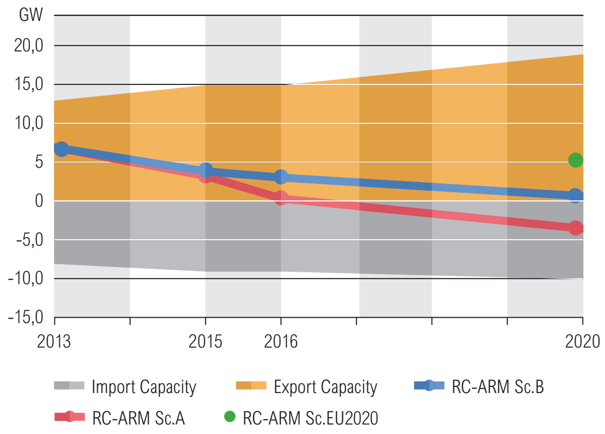



Figure 6.13:
RC - ARM Comparison France,
Scenarios A, B and EU 2020, January 7 p.m.

The following general comments have been provided regarding **Scenario EU 2020**:

This Scenario is drawing a high vision for RES development, and a large implementation of efficient energy saving measures. It is based on the figures mentioned in the French NREAP, although the installed capacities of RES are not exactly the same as in this document. These capacities depend on the likelihood of the development of the different fields, regarding the current installed capacities.

The following general comments have been provided regarding **Vision 1**:

The political context is not favourable to the development of renewable energies, mainly due to financial difficulties and a resolute commitment to scaling back support initiatives: the development of renewables is slow, and growth in the more capital-intensive segments (offshore wind, marine turbines) is close to zero. This context is positive overall for nuclear generation, with the operational life of plants extended as far as possible (around 80 % of the plants) in order to reduce the investment requirement.

The following general comments have been provided regarding **Vision 3**:

Vision 3 differentiates itself with a major commitment to overall demand-side energy management and a rapid transformation of the French energy landscape.

Significant efforts are made to enable the more widespread use of demand-side management. This also encourages new electricity uses (particularly heat pumps and electric vehicles), as well as strong growth in renewable energies and a significant downsizing of the nuclear fleet via the decommissioning of a portion of the plants nearing the end of their operational lives.

The economic environment and a marked change in the generation mix require the development of interconnection capacity.

## Generating Capacity

The following assumptions have been made to build **Scenario A**:

The NGC decreases every year from 2013 to 2020. The main hypotheses explaining this result are the following:

- *fossil fuels:* The implementation of European directive IED, as well as the end of special dispensations to the previous directive (LCP) for some units, will lead to the shutdown of more than 7 GW of hard coal and oil units between 2013 and 2016. In addition to this, more than 1 GW of CHP units are expected to be shut down between 2013 and 2020, due to changes in financial incentives. The only new units considered for installation are 1.4 GW of CCGT units;
- *Renewable energy sources:* The conservative hypothesis is a constant capacity of RES between 2013 and 2020;
- *Non Renewable Hydro:* constant between 2013 and 2020.

The following assumptions have been made to build **Scenario B**:

In this Scenario, the NGC does not decrease between 2013 and 2020, in contrast with Scenario A. Scenario B differs from Scenario A by these main hypotheses:

- *fossil fuels:* Among the units thought to be shutting down because of LCP and IED directives in Scenario A, it is thought that 2.4 GW will close in Scenario B. With regards to the new CCGT units, one more new unit (0.4 GW) is expected to be installed before 2020;
- *Renewable energy sources:* In this Scenario, an important development of RES capacity is considered.

The following assumptions have been made to build **Scenario EU 2020**:

- fossil fuels: In this Scenario, hypotheses regarding the shutdown of hard coal and oil units are the same as in Scenario A (massive shutdown). An additional 0.4 GW of new CCGT units is considered (similar to Scenario B);
- Renewable energy sources: The development of wind power is consistent with the French NREAP; for biomass and solar power, a faster development than in the NREAP can be expected, meaning that the installed capacities in 2020 are higher. Hydro power is not expected to progress significantly by 2020, and thus the capacity does not reach the values from NREAP;
- The overall volume of renewable is superior to the French NREAP target.

## Unavailable Capacity

The following assumptions have been made to build **Scenario A** and **Scenario B**:

- 70 % of the installed wind capacity is considered as unavailable on average in January, 80 % in July;
- 60 % of the installed solar capacity is considered as unavailable on average at 11 a.m., 100 % at 7 p.m.;
- A part of hydro capacity is considered as unavailable on average;
- Fossil fuel unavailability (maintenance and outages) are calculated from historical average data.

## Load

The following assumptions have been made to build **Scenario A** and **Scenario B**:

This year, in comparison to previous editions of the study, a main feature of the analysis is the drop in demand growth which has resulted from the economic crisis since 2011.

The following assumptions have been made to build **Scenario EU 2020**:

Load is lower than in Scenarios A and B, resulting from efficient energy saving measures, consistent with the general objectives of this Scenario. Even though the annual energy demand remains globally the same compared to the previous SO&AF, certain revisions have been made regarding distribution of the load during the year. Indeed, the recent dynamics of electric heating, leading to a continuous increase of the peak demand, have been considered. In light of this, the demand for the reference point January 7 p.m. is higher than in the previous SO&AF. On the other hand, the load at the July reference point has been revised to a lower value, due to the consideration of the consequences of the recent economic crisis.

## Generation Adequacy

The following assumptions have been made to build Scenario A:

- With this Conservative Scenario, Remaining Capacity minus Adequacy Reference Margin will significantly decrease from now to 2020, whilst security of supply could be threatened as early as 2015 or even sooner;
- For Spare Capacity, 7.5 % of NGC is applied;
- Margin Against Seasonal Peak Load: Low values for the winter reference time show that peak demand will still take place around 7 p.m. in winter.

The following assumptions have been made to build **Scenario B**:

- Remaining Capacity minus Adequacy Reference Margin will significantly decrease from now to 2020. It should be connected to the conclusion of the 2012 update of the French generation adequacy report, which states that in light of the new forecasts for consumption and generation, security of supply looks reasonably assured through to the 2015 timeframe, although it might be at risk from 2016. More information is available at:
  http://www.rte-france.com/uploads/Mediatheque_docs/vie_systeme/annuelles/ bilan_preVisionnel/an/generation_adequacy_report_2012.pdf
- For Spare Capacity, 7.5 % of NGC is applied;
- Margin Against Seasonal Peak Load: Low values for the winter reference time show that peak demand will still take place around 7 p.m. in winter.

The following assumptions have been made to build **Scenario EU 2020**:

- Remaining Capacity minus Adequacy Reference Margin will significantly decrease from now to 2016, but will increase again by 2020 due to the massive development of RES and a very slight increase in load;
- For Spare Capacity, 7.5 % of NGC is applied;
- Margin Against Seasonal Peak Load: Low values for the winter reference time show that peak demand will still take place around 7 p.m. in winter.

## 6.14 GB – Great Britain

The EU 2020 Scenario is based on the Gone Green Scenario developed for the UK by National Grid. Gone Green has been designed to meet UK environmental targets; 15 % of all energy from renewable sources by 2020, greenhouse gas emissions meeting UK Government carbon budgets out to 2027, and an 80 % reduction in greenhouse gas emissions by 2050.

The EU 2020 Scenario and Scenario B, the 'Best Estimate', are identical.

Generation capacity and load data are all for the National Grid transmission system and do not include generation connected to lower voltage distribution networks. The data represent around 90 % of the total GB electricity market.

### Generating Capacity

- The only new capacity included in Scenario A is that which is already under construction or where the project is too far advanced to be cancelled;
- The oldest nuclear station (0.5 GW) is closed by 2014. The rest of the nuclear fleet will remain open beyond 2020;

- Between 8 GW and 9 GW of coal and oil plants will close between 2013 and 2015 in response to the Large Combustion Plant directive (LCPD);
- In Scenario A, 1 GW of existing coal plants converted to run entirely on biomass will close at the end of 2015 due to the LCPD. In Scenarios B and EU 2020 0.7 GW is relicensed to run beyond 2015. In addition, 1.2 GW of new biomass plants will be built by 2020;
- In Scenario A, 3 GW of gas plants (CCGT and CHP) will close by 2020. In Scenarios B and EU 2020 5 GW of existing gas fired plants close, although this is more than balanced by 6 GW of new gas plants;
- No CCS plant on gas or coal generating capacity is built before 2020;
- In Scenarios B and EU 2020, 13 GW of offshore wind and 6 GW of onshore wind capacity is built between 2013 and 2020;
- There is no significant development of tidal or wave capacity, nor is there a significant increase in the existing hydro or pumped storage capacity.

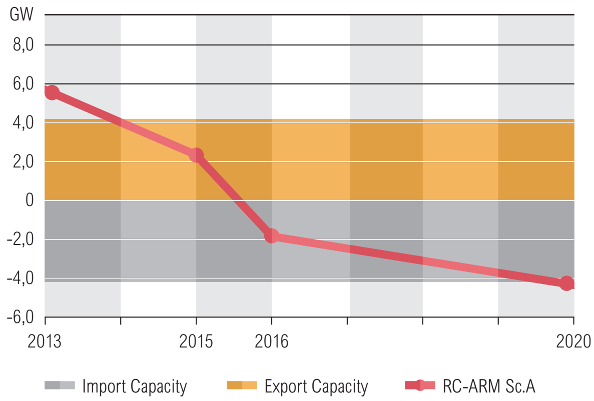



Figure 6.14.1:
RC-ARM Comparison Great Britain,
Scenario A, January 7 p.m.

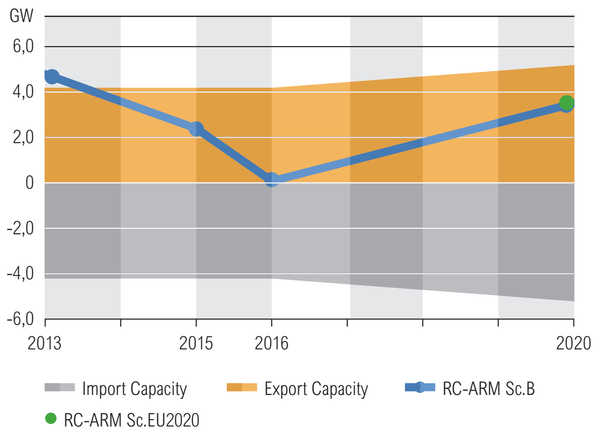



Figure 6.14.2:
RC-ARM Comparison Great Britain,
Scenario B and EU 2020, January 7 p.m.

## Unavailable Capacity

No comments provided.

## Load

There are many different factors, both positive and negative, which affect the development of electricity demand. However, the net effect of these is a small change in demand between 2013 and 2020.

- In Scenarios B and EU 2020 there is an ambitious roll out of domestic heat pumps but not until the mid-2020s. These pumps are replacing inefficient electric resistive heating which leads to a decrease in electricity demand;
- There are further reductions due to efficiency gains in domestic appliances and the replacement of incandescent bulbs with low energy lighting;
- -Economic growth in the non-domestic sector leads to an increase in demand;
- By 2020 there is a significant increase in the Electric Vehicle market;

– There is also an increase in generation, although this is not connected to the National Grid transmission system.

### Generation Adequacy

In the fully liberalised GB market there are no national adequacy standards which correspond directly with those being calculated in this document. There are planning standards to plan the long-term development of the system and to ensure that adequate Transmission capacity is available. There is no mechanism in the GB market to fund generation over and above the reserve capacity that the System Operator contracts for. In essence, it is for the market to provide adequate generation and respond to the relevant market signals. Our long-term plans consider the prospective generation projects which could potentially be developed and assumes that the market responds to the relevant signals.

In November 2013 the UK Government introduced an Energy Bill to parliament which, if implemented, will create a generation capacity market. This market will in turn allow for capacity auctions from 2014 for the delivery of capacity in the winter of 2018/19. This will result in certain changes to the market structure detailed above.

The generation capacity required in the long-term Scenarios is assessed against a long-term planning margin of approx. 20 % (wind de-rated to 5 %) and a de-rated margin of between 8 % and 12 % where all capacity is de-rated against an assessment of expected availability. More detail regarding the levels of availability which may be expected and the analysis which underpins this assessment can be found in National Grid's Winter Outlook publication.

### Interconnection Capacity

In Scenarios B and EU 2020 there is 1 GW of new interconnection to Belgium during the analysis period.

## 6.15 GR – Greece

All data provided by IPTO refers solely to the system of the mainland and the islands which are interconnected to it.

For the construction of all Scenarios it is thought that by the year 2016 the Cyclades islands will be interconnected to the mainland system, while the island of Crete will be interconnected in the year 2019.

### Generating Capacity

There are currently two mechanisms considering new generation in the Greek system: the market-driven mechanism and through tenders by IPTO to ensure adequacy. The values presented here for the years after 2016 are indicative.

The generation license granted to PPC (Public Power Corporation) together with recent legislation, allows PPC to substitute existing old generating units with new capacity of the same magnitude. PPC has announced a large-scale program, through which it plans to install new generating capacity, whilst simultaneously decommissioning old inefficient units (mainly lignite and oil units). This plan has been taken into account in the construction of all Scenarios.

The following assumptions have been made to build **Scenario A** and **Scenario B**:

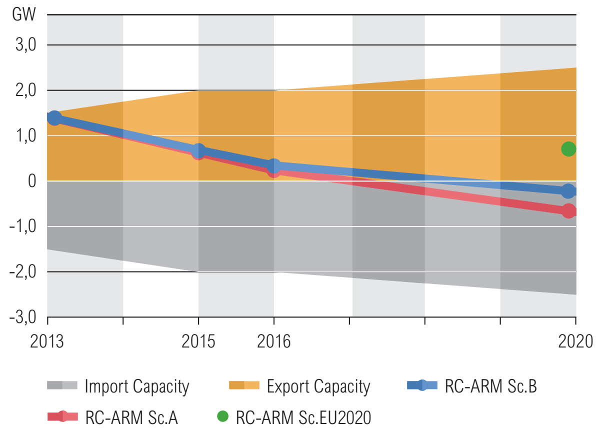



Figure 6.15:
RC-ARM Comparison Greece,
Scenarios A, B and EU 2020, January 7 p.m.

Due to the prolonged economic crisis and the limited funding of projects through banks, no new investments in thermal units are anticipated up to the year 2020, besides the projects which are already being constructed, or have already been contracted. Due to this, thermal NGC is considered the same in both Scenarios A and B.

When considering renewable energy sources, and in view of achieving national targets set for 2020, new legislation has given strong motivation for the installation of RES, as well as simplifying licensing procedures. A large number of RES projects have been announced by investors. Scenario A assumes that a small portion of these will be realised, while in Scenario B it is assumed that a larger portion of these will be realised (including RES projects on islands which will be interconnected in the time frame examined).

The following assumptions have been made to build **Scenario EU 2020**:

Data for the construction of Scenario EU 2020 has mainly been obtained from the Greek NREAP and its accompanying Committee Working Paper, providing detailed background information on the assumptions made. It should be noted that the Greek NREAP refers to the entire country and therefore all values have been appropriately scaled down in order to reflect only the interconnected mainland system (and the islands interconnected to it).

The values provided for loads and RES in Scenario EU 2020 are higher than those provided in SO&AF 2012–2025. This is done so as to include the loads and RES of Crete, which is expected to be interconnected to the mainland in 2019. In SO&AF 2012–2025 this is foreseen to be realised after 2020.

The following assumptions have been made regarding **Vision 1**:

Regarding thermal NGC, Vision 1 has been constructed based on the guidelines provided. It is assumed that most new projects are CCGTs.

On-going licensing procedures and implementation of RES projects indicate that photovoltaic projects are realised at a considerably higher rate than anticipated. Indeed, it is expected that by the year 2020 the installed capacity of photovoltaics will exceed the set target of Greek NREAP. On the other hand, the installation of wind parks does not seem to be proceeding as anticipated. Due to this, installed capacities of wind parks and photovoltaic have been appropriately altered in order to reflect these trends, while still maintaining the same set targets of RES generation for the year 2020.

The following assumptions have been made regarding **Vision 3**:

Vision 3 has been constructed based on the ENTSO-E guidelines provided.

### Unavailable Capacity

The Non-Usable Capacity includes mainly hydro capacity (which is reduced due to limited water reserves) and capacity of wind power plants (an average of 75 % of which is non-usable during the summer peaks). Water management aims to save water reserves so that they can be used at the peak demand and only along with irrigation management.

Furthermore, it is considered that solar units do not contribute at the first reference point (3rd Wednesday of January at the 19th hour).

Additionally, the limited availability of thermal units due to temperature (heat) is considered for the second reference point (3rd Wednesday of July at the 11th hour).

The overhauls of the thermal power plants are avoided during periods of high demand. In this assessment, a provisional overhaul schedule of the thermal units has been considered. The overhauls of the hydro power plants are implemented during periods of low use, which means low water reserves or low load periods. Therefore, the scheduled outages of the hydro power plants do not affect the remaining generating capacity.

### Load

Due to the prolonged economic crisis, the growth rate of electricity demand in Greece has decreased considerably in comparison with previous years.

Loads provided for every Scenario refer to the total demand (loads at the transmission level, as well as dispersed generation from RES at the distribution level) for the mainland and the interconnected islands.

The following assumptions have been made to build **Scenario A** and **Scenario B**:

Values provided are obtained from the most recent load forecasting studies performed by IPTO.

The following assumptions have been made to build **Scenario EU 2020**:

The values provided are obtained from the national NREAP and are adapted appropriately in order to reflect only the interconnected system of the mainland (and the islands interconnected to it)

The following assumptions have been made regarding Vision 1:

Values provided are obtained from the draft version of the national 'Roadmap to 2050' and are adapted appropriately in order to reflect only the interconnected system of the mainland (and the islands interconnected to it).

The following assumptions have been made regarding **Vision 3**:

Values provided are obtained using the methodology provided in the guidelines.

### Generation Adequacy

It can be seen than RC is positive for every year of the studied period, thus meaning that the Greek system seems to be sufficiently adequate and some generating capacity will be available for exports under normal conditions. However, the lack of new investments in thermal plants, together with the additional load, which must be met due to the interconnection of certain islands, leads to a declining value of the RC index over the years.

For Scenarios A and B, the index RC-ARM is positive up to the year 2016, suggesting that security of supply is likely to be guaranteed in most situations, while exports may be possible even under severe conditions. For both Scenarios the index RC-ARM turns negative in the year 2020, meaning it is more than likely that the Greek power system will have to rely on imports when facing seasonal peaks.

For Scenario EU 2020 the index RC-ARM is positive, despite the fact that higher loads are assumed compared to Scenarios A and B. This is a result of the considerably higher level of RES penetration assumed, mainly of wind parks, which seems to guarantee security of supply in most of the situations.

## 6.16 HR – Croatia

### Generating Capacity

The following assumptions have been made to build **Scenario B**:

Data relating to the planned installed capacity of hydro power plants and other renewable energy sources are taken from the draft of The National Renewable Energy Action Plan (NREAP):

- The installation of a new hydro power plant and the revitalisation of those already in existence is planned for 2020. This would increase the installed capacity of HPP by approximately 400 MW;
- In the year 2020 the installed capacity of wind power plants is planned to be 1,200 MW;
- In the year 2020 installed capacity of other RES is planned to be 300 MW (100 MW of biomass +200 MW of the other RES).

Data regarding the planned installed capacity of power plants using fossil fuels are taken from the Croatian Energy Development Strategy which provides:

- The commissioning of new thermo power plants rated 2,400 MW by the year 2020;
- The decommissioning of the existing thermo power plants rated 1,100 MW by the year 2020.

The following assumptions have been made to build **Scenario A**:

The installed capacity of hydropower plants and other RES (except wind) is the same as that for Scenario B.

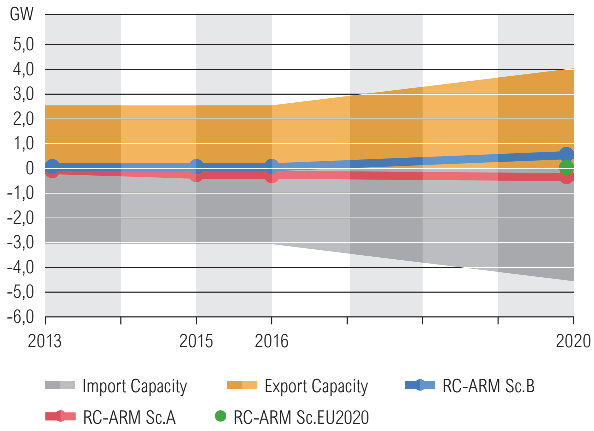



Figure 6.16:
RC - ARM Comparison Croatia,
Scenarios A, B and EU 2020, January 7 p.m.

In the year 2020, the installed capacity of wind power plants is planned to be 800 MW.

Compared to Scenario B, it is estimated that the installed capacity of coal power plants will be lowered by 500 MW.

The following assumptions have been made to build **Scenario EU 2020**:

Data relating to the planned installed capacity of hydro power plants and other renewable energy sources are taken from a draft of The National Renewable Energy Action Plan (NREAP):

- The installation of a new hydro power plant and the revitalisation of those already in existence is planned for 2020. This would increase the installed capacity of HPP by approximately 400 MW;
- In the year 2020 the installed capacity of wind power plants is planned to be 1,200 MW;
- In the year 2020 installed capacity of the other RES is planned to be 300 MW (100 MW of biomass +200 MW of other RES);
- Installed capacity of RES makes it possible to achieve the national target of 35 % of total electricity demand in the year 2020;
- Data regarding the planned installed capacity of power plants using fossil fuels are the same as for Scenario A.

The following assumptions have been made regarding **Visions 1 and 3**:

The period until 2030 will be characterised by increased construction of HPP and Renewable Energy capacities, with the aim of reducing $CO_2$ emissions.

### Unavailable Capacity

Depending on hydrological circumstances and availability of renewable energy sources (of which the installed capacity in the amount of net generating capacity will increase its share constantly) the constant increase of unavailable capacity is expected. A contribution to this will also come from regular maintenance works on the generation facilities as well as continuous increase of the necessary amount of System Service Reserve. This trend will be more significant due to the lack of usable capacity in old TPP units, which will gradually cease operations.

### Load

Load forecast has been built taking into account the medium- and long-term projections of economic growth rate. Growth of the load depends directly on industry development and the growth in household consumption. Significant investments in energy efficiency are expected, thus slowing the growth of electricity consumption.

### Generation Adequacy

Spare capacity will be in the range of approximately 5 % of Net Generation Capacity, i.e. from 200 MW in 2013 to an expected 400 MW in 2020.

The following assumptions have been made to build Scenario B:

Remaining capacity will increase significantly in the year 2020, primarily due to increased volume of power plants using fossil fuels.

The following assumptions have been made to build Scenario A:

Remaining capacity will remain at the same level during the period 2013 – 2020.

### Interconnection Capacity

The new substation project 400/110 kV Lika will facilitate the connection of RES. Substation Lika is a precondition for the new interconnection with Banja Luka in Bosnia and Herzegovina. OHL 400 kV Banja Luka – Lika will increase cross-border capacity, support market integration, improve security of supply and support conventional generation integration.

The eventual installation of phase shift transformers (PST) in some of the border substations is also under consideration.

The construction of an HVDC submarine cable with a capacity of 500 to 1,000 MW between Dalmatia in Croatia and Italy is under consideration on the long-term horizon.

## 6.17 HU – Hungary

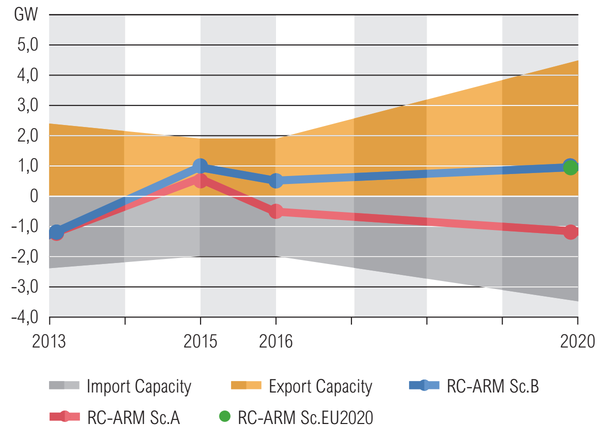



Figure 6.17:
RC-ARM Comparison Hungary,
Scenarios A, B and EU 2020, January 7 p.m.

## 6.18 IE – Ireland

Following completion of the 2nd North-South tie-line, currently planned to be operational by 2017, the transmission systems for both Ireland and Northern Ireland can be considered as a single system. As these jurisdictions also currently share reserve requirements and operate in a single electricity market, the responses for the two jurisdictions have been coordinated as much as possible for all Scenarios.

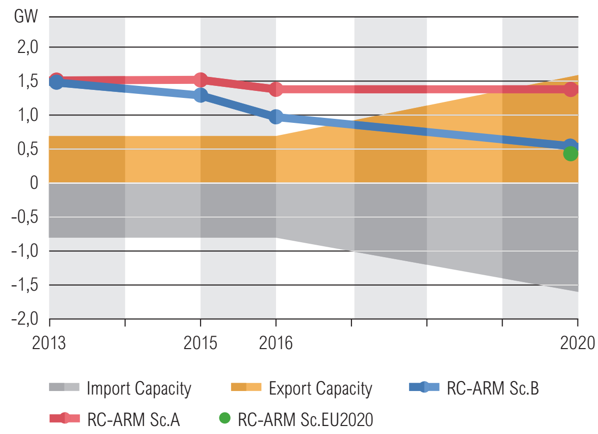



Figure 6.18:
RC-ARM Comparison Ireland,
Scenarios A, B and EU 2020, January 7 p.m.

### Generating Capacity

In Scenario A, decommissioning dates are based on notification from generators. In Scenarios B and EU 2020, decommissioning dates have been estimated based on notification from generators and the age of generators.

### Unavailable Capacity

Unusable capacity is generally attributable to wind generation and other small-scale generation. The value of installed wind capacity is estimated in terms of a thermal plant permanently operable at full capacity. It is called the 'wind capacity credit'. The difference between installed wind capacity and wind capacity credit is entered as unusable capacity.

System Service reserve is based on the largest system in-feed on the island of Ireland, and is shared 3:1 with Northern Ireland. The largest single in-feed is expected to be 500 MW, meaning that Northern Ireland provides 125 MW and Ireland provides 375 MW of reserve.

### Load

Load figures for Scenarios A and B are based on an economic model, as prepared for the annual Generation Capacity Statement.

The growth rates used for Scenario EU 2020 follow those presented in Ireland's NREAP report. However, overall figures differ slightly, as we have used a different starting point.

The annual peak demand occurs in winter and the forecast assumes average winter temperatures. The forecast peaks already account for demand reduction measures.

### Generation Adequacy

In all Scenarios, the adequacy situation is positive for all years.

### Interconnection Capacity

After 2017, the figure includes an additional 1,000 MW Import and Export interconnection with Northern Ireland due to completion of the 2nd North-South tie-line, currently planned to be operational by 2017. We already operate under a single electricity market with Northern Ireland.

## 6.19 IS – Iceland

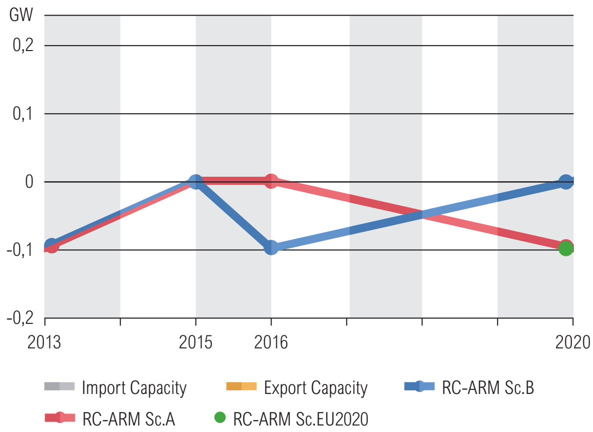



Figure 6.19:
RC - ARM Comparison Iceland,
Scenarios A, B and EU 2020, January 7 p.m.

## 6.20 IT – Italy

### Generating Capacity

A capacity increase reaching approximately 9 GW in conventional thermal power plants is expected between 2013 and 2020 under Scenarios A and Scenario B. In Scenario EU 2020, the variation between 2013 and 2020 is restrained to approximately 2 GW. For Vision 1 and Vision 3, the estimated figures for conventional thermal power plants on 2030 still remain about the same as the EU 2020 value.

Due to the impressive development of solar generating capacity, for all Scenarios A, B, and EU 2020, we take figures of 23 GW in 2016 and 30 GW in 2020. For Vision 1 and Vision 3 we take 30 and 42 GW respectively in 2030. In addition, all of these values could be affected by an uncertainty of approximately one or two GW, due to the rapid solar development in the Italian system.

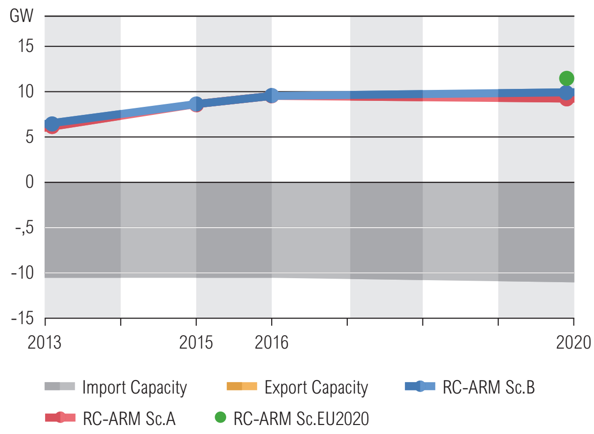



Figure 6.20:
RC-ARM Comparison Italy,
Scenarios A, B and EU 2020, January 7 p.m.

Another effect of the great spread of renewable source of energy could be a delay, and possibly a decrease in the estimated deployment of new conventional generation, particularly with regard to the power plants which are still not under construction at the present time.

In the long-term Scenarios the possible presence of new pumping capacity is under study, in order to allow for the full use of unpredictable renewable energy sources. Therefore, during the next years the pumping capacity could be updated.

For the EU 2020 Scenario in particular, other renewable (except for PV power plants) sources have been treated according to the Italian National Renewable Energy Action Plan, presented by Italian Ministry of Economic Development on 30 June 2010.

### Unavailable Capacity

No comments provided.

### Load

For a better estimation of the power in order to cover future demand, we consider the same evolution for both Scenario A and Scenario B. A lower level of load has been proposed for EU 2020 Scenario, according to an expected lower level of electricity energy demand. For Vision 1, load level has the same magnitude as today, whereas for Vision 3 the estimated figure is moderately higher than the level reached for 2020 in Scenarios A and B.

## Generation Adequacy

In normal conditions the remaining capacity in most of the contingencies will be sufficient. This value can be higher if the full import capacity is considered. The spare capacity is assumed to be 5 %.

## Interconnection Capacity

The figures have been built considering all planned facilities included within the National Development Plan of Terna.

# 6.21 LT – Lithuania

## Generating Capacity

Following the definition of Scenario A, no new fossil fuel generating capacities are taken into consideration, except the connection of a new 420 MW CCGT unit at the end of 2012. RES development is obtained by using information from the National Renewable Energy Action Plan (NREAP).

For the Best Estimate Scenario B few new power units complemented, the construction of which is reasonable from the TSO's point of view. RES development is assessed following the actual amount of technical requirements provided for Wind PP connection to the network.

EU 2020 is almost the same as Scenario A, except for RES development. It is already clear today that RES capacities, indicated in the NREAP for 2020, will be reached in 2015. Consequently, in the EU 2020 Scenario RES capacity is enhanced.

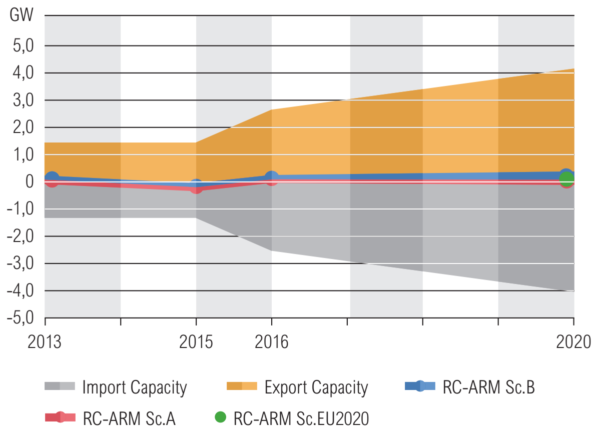



Figure 6.21:
RC - ARM Comparison Lithuania,
Scenarios A, B and EU 2020, January 7 p.m.

The decommissioning of old units is evaluated in all Scenarios, and is based on information provided by generating companies (annual survey performed).

For Vision 1 the decommissioning of old units (end of unit lifetime) is estimated and no generation development is foreseen.

For Vision 3 the construction of a new 1,350 MW installed capacity nuclear unit is estimated. Such an objective is set in the National Energy Independence Strategy of the Republic of Lithuania.

In Scenarios A and EU 2020 and Vision 1, fossil fuel NGC is decreasing during the examined period. This is related to the expiration of the useful lifetime of generating units. For Scenario B and Vision 3 the replacement of old units by new is foreseen, with the effect visible in the increase of fossil fuel based capacity by the end of the analysed period, starting in the year 2018.

### Unavailable Capacity

Unavailable capacity includes 94 % of wind power capacity and 75 % of HPSPP NGC. It is assumed that maintenance and overhauls will take place during the summer period. During the period 2013 – 2016 the largest PP in Lithuania has declared its intention to suspend the maintenance of old units. A decrease in RAC during this period is visible.

### Load

Load forecast is based on GDP growth forecast, as the main factor influencing energy demand is change of the GDP. It is assumed that load for Scenarios A, B and EU 2020 will be identical.

### Generation Adequacy

For all three Scenarios (A, B and EU 2020) RC remains positive for the entire analysed period. However, for the years 2014 and 2015, generation adequacy requirements are not satisfied. In 2014 there is a 150 – 180 MW lack of generating capacity in winter peak time and a 130 – 160 MW lack at the summer reference point. However, even if Lithuania has sufficient capacity to cover peak demand (except 2014 – 2015 period), local generation costs are not competitive compared to import electricity costs (mostly from Russia).

### Interconnection Capacity

In each scenario, a new 400 kV double circuit line to Poland (LitPol Link project) as well as a new 300 kV submarine cable line to Sweden (NordBalt project) is assumed. The operation of the LitPol Link interconnection is expected to commence in December 2015, while the NordBalt interconnection (700 MW capacity) is expected to be in operation in 2016.

Lithuania currently has no connection to the European network. The construction of these interconnections is very important for ensuring security of supply and integration into the European electricity market for both Lithuania and the Baltic region (Lithuania, Latvia, and Estonia).

## 6.22 LU – Luxembourg

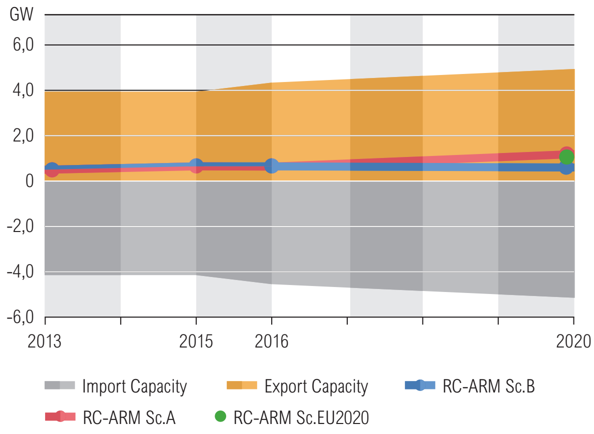



Figure 6.22:
RC-ARM Comparison Luxembourg,
Scenarios A, B and EU 2020, January 7 p.m.

## 6.23 LV – Latvia

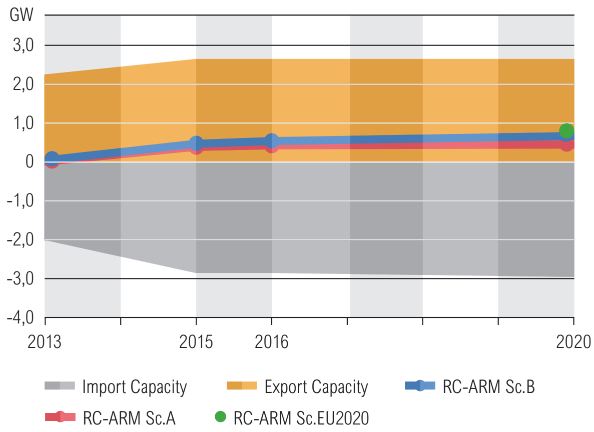



Figure 6.23:
RC-ARM Comparison Latvia,
Scenarios A, B and EU 2020, January 7 p.m.

## 6.24 MK – Former Yugoslav Republic of Macedonia (FYROM)

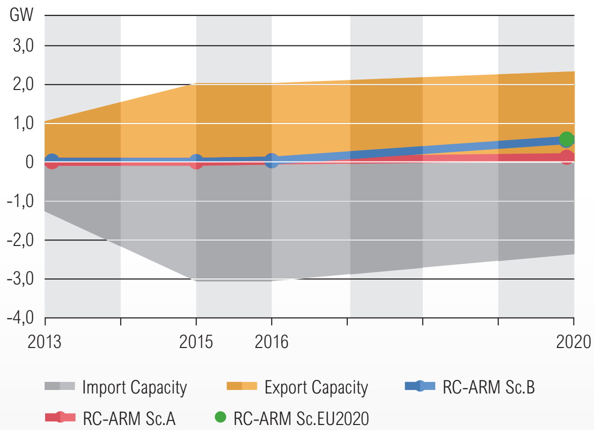



Figure 6.24:
RC-ARM Comparison Former Yugoslav Republic of Macedonia,
Scenarios A, B and EU 2020, January 7 p.m.

## 6.25 ME – Montenegro

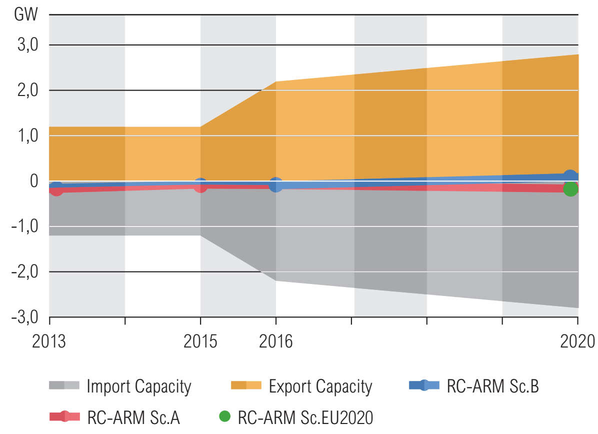



Figure 6.25:
RC-ARM Comparison Montenegro,
Scenarios A, B and EU 2020, January 7 p.m.

## 6.26 NI – Northern Ireland

Following completion of the 2nd North-South tie-line, currently planned to be operational by 2017, the transmission systems for both Northern Ireland and Ireland can be considered as a single system. As these jurisdictions also currently share reserve requirements and operate in a single electricity market, the responses for the two jurisdictions have been coordinated as much as possible for all Scenarios.

Northern Ireland does not have its own specific NREAP. Energy matters in Northern Ireland are devolved to the Northern Ireland Assembly. Within the Northern Ireland Government, the Department of Enterprise, Trade and Investment (DETI) is responsible for Energy matters in Northern Ireland. Following the publication of a 'Strategic Energy Framework for Northern Ireland'[13)], DETI has also published a Sustainable Energy Action Plan[14)]. The EU 2020 Scenario has been generated from these documents.

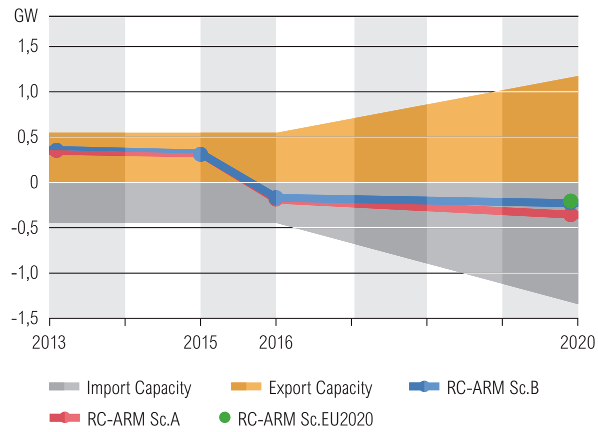



Figure 6.26:
RC-ARM Comparison Northern Ireland,
Scenarios A, B and EU 2020, January 7 p.m.

13) http://www.detini.gov.uk/strategic_energy_framework__sef_2010.pdf

14) http://www.detini.gov.uk/03may.pdf

## Generating Capacity

510 MW of “Fossil Fuel” generation will be decommissioned by the end of 2015. 333 MW of generation is included as “Oil”, although it should be noted that this is distillate and not heavy oil. “Not Clearly Identifiable” consists of small-scale embedded generation.

## Unavailable Capacity

Unusable Capacity is due to wind generation and other small-scale generation. The value of installed wind capacity is estimated in terms of a thermal plant always operable at full capacity. This is referred to as ‘wind capacity credit’. The difference between installed wind capacity and wind capacity credit is entered as unusable capacity.

System Service reserve is based on the largest system in-feed on the island of Ireland, and is shared 1:3 with Ireland. The largest single in-feed is expected to be 500 MW, meaning that Northern Ireland provides 125 MW and Ireland provides 375 MW of reserve.

## Load

The Northern Ireland load forecast is temperature corrected to an average cold spell (ACS) with a normal underlying economic growth rate of 1.5 %, applied from 2015 onwards. This forecast is used in our annual generation capacity statement.

In Scenario EU 2020 loads have been reduced by 1 % from the Scenario B loads in line with a 1 % efficiency target as set out in the Strategic Energy Framework for Northern Ireland[15].

In forecasting annual peak and calculating margin against peak load, our models already account for load management. We have therefore left this as zero to avoid double counting; however, it is typically approximately 45 MW during winter peak hour.

## Generation Adequacy

In all Scenarios, the Northern Ireland adequacy position is positive up until 2016, from which point Northern Ireland becomes reliant on imports from Great Britain and Ireland. This is mainly due to the decommissioning of 510 MW of generation at the end of 2015 due to the Large Combustion Plant Directive. There are no new large scale conventional generating units expected to be commissioned in Northern Ireland for the foreseeable future.

Margin against Peak Load values assume average winter temperatures.

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15) http://www.detini.gov.uk/strategic_energy_framework__sef_2010_.pdf

### Interconnection Capacity

After 2017, the figure includes an additional 1,000 MW Import and Export interconnection with Ireland due to completion of the 2nd North-South tie-line, currently planned to be operational by 2017. We already operate under a single electricity market with Ireland.

## 6.27 NL – The Netherlands

### Generating Capacity

The installed thermal generation capacity in the Netherlands in the Conservative Scenario (A) in 2020 is extending more than 20 % in comparison with the year 2012 (24 GW) towards 30.2 GW. The present 2.8 GW renewable power should be constant (wind power 2.3 GW).

Scenario B shows an amount of 30.4 GW of thermal generation capacity in 2020; an approximate growth of 25 % in comparison with the year 2012. The extending generation capacity can be distinguished into 3.3 GW coal and 3.8 GW gas fired units whilst 1.1 GW will be decommissioned. This Best Estimate generation Scenario also includes an increasing amount of 3.7 GW of wind power towards 6 GW in 2020.

The Scenario EU 2020 is based on the Dutch National Renewable Action Plan (NREAP). In this NREAP the total value of renewable supply (15.0 GW, including 1 GW hydro and solar) is translated into the Scenario EU 2020 in two separate parts: 12.7 GW renewable capacity by primary fuel capacity and 2.2 GW renewable by secondary fuel capacity, the latter being biomass in coal fired units. The waste incineration capacity can be distinguished into renewable capacity (biogenic fraction) and non-renewable capacity (non biogenic fraction). The total amount of wind power in 2020 is estimated at more than 11.1 GW. Other basic principles taken into account are derived from the Best Estimate Scenario.

Thus, the NGC in 2020 shows nearly 34.1 GW in Scenario A and 38.1 GW in Scenario B. However, 2.5 GW will be mothballed according to the 2012 reports from producers. For Scenario EU 2020 the

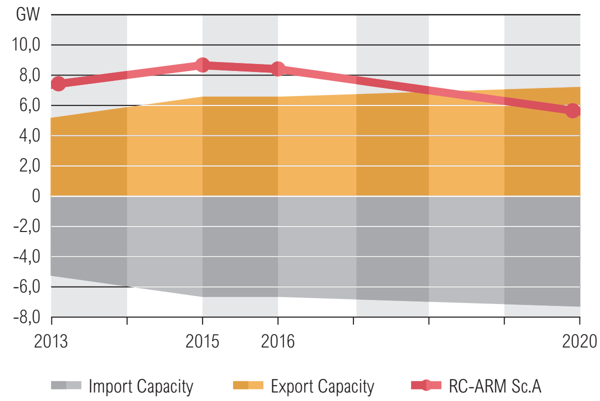


Figure 6.27.1:
RC - ARM Comparison The Netherlands, Scenario A, January 7 p.m.

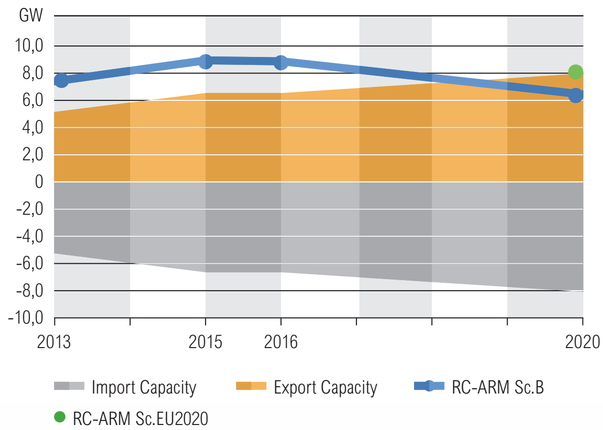


Figure 6.27.2:
RC - ARM Comparison The Netherlands, Scenario B and EU 2020, January 7 p.m.

NGC in 2020 will be 44.2 GW, primarily due to onshore and offshore wind capacity extension.

### Unavailable Capacity

The difference of the NGC in 2020 between Scenarios A and B (resp. 34.1 GW and 38.1 GW) is mainly due to wind capacity growth (3.7 GW). Besides maintenance, overhauls, outages, mothballing and system services are taken into account. The reliable available capacity (RAC) is calculated very conservatively because of the wind capacity factor. The unavailable capacity in Scenario A totals 7 GW in Scenario B 10 GW and in Scenario EU 2020 even more than 14 GW.

### Load

The development of load in Scenario A and B is based on historic growth figures of electricity consumption and realised economic growth rates, including the consumption dip impact resulting from the economic crisis. The basic assumption for the load assessment applied in this report is using the historic load pattern on the one hand and the total annual demand on the other hand. The assessment of the winter and summer load peak 2020 in Scenario A and B will be based on a 1.5 % annual growth rate as from 2012. In Scenario EU 2020, the load values for Scenarios SAF and B are downscaled based on the ratio of the electricity consumption in the energy efficiency scenario of the Dutch NREAP and the electricity consumption forecast by the TSO, resulting in an average growth rate of 0.9 % in this scenario.

### RC, ARM and RC-ARM

The development of the NGC in all Scenarios will increase more strongly and the remaining capacities (RC) will not show a negative value, even in the Conservative Scenario. The RC 2020 for Scenario A is 11.5 GW in summer times and 9.5 GW in winter times. In Scenario B the RC in the summer period is 12.5 GW and in the winter period the RC is 10.5 GW. Finally, with regard to Scenario EU 2020, the RC in summer times is 14.5 GW and in winter times 12.5 GW. The Adequacy Reserve Margin (ARM) has a range of 3.9 to 4.7 GW in 2020.

Thus, it could be foreseen that there will be a certain comfortable space for updating the installed generation capacity by replacing old or insufficient units. This process would be sped up when the development of load can be reduced by savings according to the Scenario EU 2020.

### Transportable/Interconnection Capacity

Extending interconnection capacities for the Netherlands:

In 2011 the BritNed cable operated commercially: a HVDC bipolar installation including 260 km of 450 kV DC subsea cable between the UK (Grain) and the Netherlands (Maasvlakte) with an increase of 1.0 GW NTC. This is the first electricity connection between the UK and the Netherlands. It is designed to enhance diversity and security of supply for both markets. It also aims to achieve open access for all market parties by explicit auction and market coupling increase of interconnection capacity and market transparency.

A new 400 kV double circuit interconnection 60 km line between Germany (Niederrhein) and the Netherlands (Doetinchem) is foreseen in 2015 with increasing NTC as from 1.5 GW as a result of overloads due to high North-South power flows through the auctioned frontier between the Netherlands and Germany in peak hours of wind in-feed. Progress status: design and permitting.

Furthermore, COBRA is also under study for design & permitting 2017 – 2018: a new single circuit HVDC connection between Denmark (Jutland) and the Netherlands via 350 km subsea cable; the DC voltage will be up to 450 kV and the capacity to 0.7 GW. There is a need to increase the current transfer capacity to allow for the exchange and integration of wind energy and increase the value of renewable energy into the Dutch and Danish power systems.

Under consideration is NorNed 2: a second HVDC connection between Norway and the Netherlands via 570 km 450 kV DC subsea cable with minimal 0.7 GW capacity. There is a need to increase the current transfer capacity between both countries for diversity of supply: connection between a hydro and a thermal power system.

## 6.28 NO – Norway

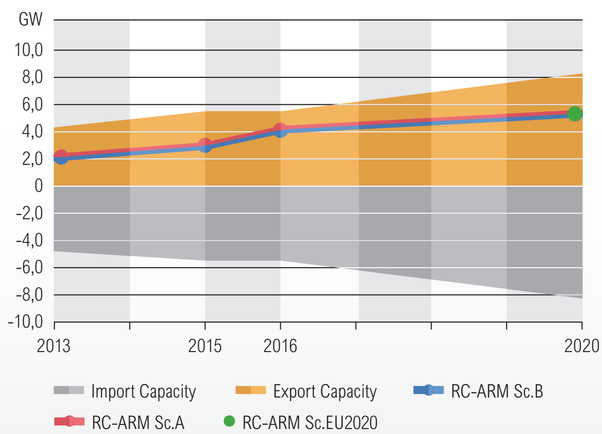


Figure 6.28:
RC - ARM Comparison Norway,
Scenarios A, B and EU 2020, January 7 p.m.

## 6.29 PL – Poland

### General information about Polish data

Input data on generation and consumption for Scenario Outlook & Adequacy Forecast (SO&AF) 2013 – 2030 was collected in October 2012.

Generation data for Scenarios A and B is based on information from producers collected in April 2012. Load data in A and B come from PSE's own analysis, prepared in December 2011.

Renewable generation data for Scenario EU 2020 come from the official National Renewable Action Plan (NREAP) prepared by the Ministry of Economy dated December 2011. Conventional generation and load data come from the Ministry of Economy's own analysis.

All values in this report are net values.

National representativeness is 100 %.

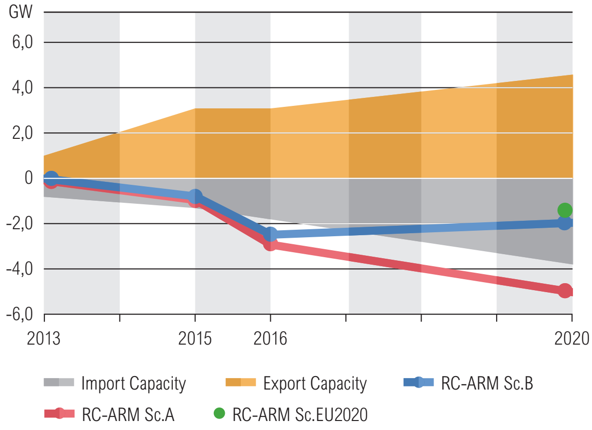


Figure 6.29:
RC - ARM Comparison Poland,
Scenarios A, B and EU 2020, January 7 p.m.

### Generating Capacity

**1. Information on the subject of derogation clause from LCP and IE directives in Poland**

During negotiations on its accession to the European Union (joined April 1, 2004), Poland achieved the derogation clause from LCP Directive (2001/80/EC), which came into effect in 2008 (for $SO_2$) and 2016 (for NOX). The derogation clause from the Directive means that the emission limit values will not apply until January 1, 2016 for $SO_2$ and January 1, 2018 for $NO_X$ for selected power stations and combined heat and power plants (CHPs). No derogation for power plants is in force for dust.

The IE Directive (2010/75/EU) amends the LPCD and the IPPCD and introduces new, more restrictive limits concerning $SO_2$, $NO_X$ and dust emissions for power plants as well as for CHPs. It will come into effect from 2016, although when taking into account the derogation described above, the new limits for $NO_X$ emission will be in force in Poland no earlier than 2018, for the same (as for LCPD) producers. The IED has not yet been implemented in Polish law.

**2. Main results of implementation of LPCD and IED on generation capacity**

The Polish TSO, based on producers' declaration, assesses that in Poland the following amount of conventional thermal capacity is to be decommissioned as a consequence of the results of LCPD and IED entering into force, as well as exceeding the life span of units:

– 3.4 GW until the end of 2015 (in SO&AF 2012 it is 2.6, in SO&AF 2011 -5.5 GW),
– 2.1 GW between 2016 and 2020, mainly until the end of 2017 (in SO&AF 2012 it was 2.1 GW, in SO&AF 2011 -4 GW) ,
– 5.0 GW is to be decommissioned between 2020 and 2030. Decommissioning after the year 2020 is mainly caused by exceeding the life span of units.

The total decommissioned conventional thermal capacity in Poland until 2030 amounts to 10.5 GW. The amount of new conventional thermal capacity depends on how many of the projects submitted to PSE will be realised. The Polish TSO assesses the level of new capacity until 2030 to amount to approximately 9 GW for both Visions. The difference between Visions in conventional thermal is the share of gas -7 % in Vision 1.25 % in Vision 3.

**3. Detailed information concerning NGC in SO&AF Scenarios**

*a) The Conservative Scenario A*

Following the ENTSO-E definition, this Scenario indicates potential unbalance owing to a lack of new investments in the future. For thermal and nuclear power plants, PSE adopts the following criterion of confirmation regarding the execution of the investment: concluding an agreement (with subcontractors) by an investor for the construction of a unit. For other generating sources, mainly wind farms, the Polish TSO has utilised the level of the net generation capacity which is to be reached within a two-year time horizon according to the Yearly Coordination Plans (system balance plans, published on PSE website).

Taking into account the criteria mentioned above, there are two newly commissioned thermal units taken into account in this Scenario -900 MW of hard coal unit and 400 MW of gas (status as of October 2012). A development of wind generation up to the level of 4 GW installed capacity is envisaged.

*b) The Best Estimate Scenario B*

NGC in this Scenario is based on information from producers with regard to the investment projects by generators and takes into account the achievable level of power capacity assessed by PSE which amounts to approximately 4.7 GW till 2020. Observed differences in dynamics of increased NGC and reliable available capacity (RAC) result mainly from the assessed unavailability rate of wind farms. Data in Scenario B for the year beginning 2013 are identical to that for Scenario A.

*c) Top-down Scenario EU 2020*

Net Generating Capacity data in this Scenario is based on the following documents:

– NREAP – for NGC of renewable energy sources (RES) for the analysed year 2020;

– Ministry of Economy own analysis – for NGC of conventional thermal PPs.

*d) Scenario Vision 1 and 3*

  – The level of capacity and generating sources structure are prepared according to guidelines for Visions construction, meaning mainly: a higher level of $CO_2$ emissions prices in Vision 3 compared to Vision 1, meaning that more gas/less coal projects must be taken into consideration in Vision 3;

  – Higher GDP in Vision 3 compared to Vision 1, which causes higher load as well as increased new capacity (other than fossil fuel) in the system in Vision 3;

  – 35 % more RES in Vision 3 compared to Vision 1.

## Load

The forecast yearly peak load (as load at reference point + margin against seasonal peak load), taking place during the winter season, develops as follows:

a) In Scenarios A and B, there is a 1.5 % annual increase
b) In Scenario EU 2020, this is 1.8 %
c) In Vision 1, 0.8 %
d) In Vision 3, the same increase is expected as in EU 2020 -1.8 %.

All above values concern yearly peak load, which will take place during the winter season. The growth of summer peak load (meaning morning peak load during the period between June and mid-August), is higher than that for the winter season by approximately 0.3 %. All comparisons are made on the basis of forecast for Scenario B in 2013.

## Generation Adequacy

The same methodology is used in all Scenarios for calculation details of unavailable capacity and Adequacy Reference Margin. This methodology, based on ENTSO-E requirements, comes from Guidelines for SO&AF Data Collection.

**1. Unavailable capacity**

Elements of unavailable capacity and short description:

*a) Non-usable capacity:*

– average factor of unavailability of onshore wind generation -79 %, for offshore -60 %;

- average factor of unavailability of solar – 100 % in January reference point, 60 % in July;
- technological limitation of production in combined heat and power plants (summer season);
- restrictions owing to cooling water temperature in certain thermal power plants (summer season);
- limitations owing to transmission network capacity constraints caused by high temperature (summer season);
- increase of the heat production in combined heat and power plants (winter season);
- part (ca. 40 %) of pump storage total availability is treated as non-usable (usage of hydro power determined by duration of peak load in winter season).

*b) Maintenance and overhauls:*

For 2013, the level of capacity concerning maintenance and overhaul schedules, as agreed between PSE and producers, is given. However, for the following years, the level is estimated in relation to the level of thermal net-generating capacity for these years.

*c) Outages:*

- forced outages;
- outages owing to unexpected faults during the start of the unit within on-going maintenance process.

*d) System Services Reserve:*

PSE sets the level of primary reserve according to ENTSO-E requirements and secondary reserve at the level of the potential outage of largest element in the system (bus bar, unit). Both reserves are kept in conventional thermal power plants.

**2. Remaining Capacity/Remaining Capacity minus Adequacy Reference Margin**

a) Scenario A
Remaining capacity (RC) in this Scenario significantly decreases, particularly after the year 2015. This results from the decommissioning caused by the LCP Directive and IE Directive coming into effect as well as the limitation of units' lifespan (only two new thermal units confirmed after the year 2013). Since the year 2015 the value of RC minus adequacy reference margin (ARM) is negative. Starting from 2016 this value exceeds forecast NTC in the import direction.

b) Most newly commissioned thermal units in Scenario B are planned beyond the year 2016, thus meaning that the trend of RC and value of RC-ARM until 2016 is approximately the same as in Scenario A. This indicates possible problems with balancing the system that year. Between 2016 and 2020, when most new units will be commissioned, RC as well as the value of RC-ARM increases.

c) Both load and NGC values are higher in Scenario EU 2020 than in Scenario B, thus meaning that RC and RC-ARM in 2020 are close to Scenario B values.

### 3. Spare Capacity

Polish TSO assumes 5 % of NGC minus the sum of maintenance and overhauls.

### 4. Margin against Seasonal Peak Load

For Poland the representative season for winter comprises December, January and February (peak load usually takes place at 5:15 p.m.).

For summer it is the period between June and mid-August with a daily peak load at 1:15 p.m. The time of occurrence of this peak load justifies the choice of the representative months for the summer period. Indeed, statistically speaking, before and after this summer period, the daily peak loads take place in the afternoon. The calculation of Margin against Seasonal Peak Load is based on statistical data and its value is constant for the forecast period.

Simultaneous Interconnection Transmission Capacity (SITC)

PSE follows a single coherent vision of cross-border interconnection development, and therefore the values presented in Scenario A are the same as in Scenario B and EU 2020. There is also no difference in NTC between the 2030 Visions: 1 and 3.

The increase of SITC indicated in 2015 for synchronous profile is the result of phase shifter installation in Krajnik and Mikułowa substations (connecting PL and DE systems) and change of voltage level for the Krajnik-Vierraden line from 220 kV to 400 kV. Another increase of SITC for this profile, in 2020, is the result of building a third 400 kV interconnection between PL and DE. For asynchronous profile, a 400 kV double circuit line Alytus-Ełk with back-to-back substation (500 MW until the end of 2015 – import to Poland only – and 1000 MW in 2020) is being considered. Additional 600 MW from UA is based on re-launch existing 750 kV connector.

| NTC[1] [MW] | 2013 | 2015 | 2016 | 2020 | 2030 |
|---|---|---|---|---|---|
| PL -> DE/CZ/SK[2] | 1,000/800[3] | 2,500 | 2,500 | 3,000 | 3,000 |
| DE/CZ/SK2) -> PL | 0 | 500 | 500 | 2,000 | 2,000 |
| PL -> UA[4] | 0 | 0 | 0 | 0 | 0 |
| UA -> PL | 220 | 220 | 220 | 220 | 820 |
| PL-LT[5] | n/a | n/a | 0 | 1,000 | 1,000 |
| LT-PL[5] | n/a | n/a | 500 | 1,000 | 1,000 |
| PL -> SE | 0 | 600 | 600 | 600 | 600 |
| SE -> PL | 600 | 600 | 600 | 600 | 600 |
| **PL export** | 1,000/800 | 3,100 | 3,100 | 4,600 | 4,600 |
| **PL import** | 800 | 1,320 | 1,820 | 3,820 | 4,420 |

[1] Values presented in the table are maximum NTC values forecast for winter/summer seasons at peak time. State as of October 2012. Capacity offered to the market may differ from values shown above.
[2] PSE gives aggregated data for the whole synchronous PL-DE/CZ/SK profile.
[3] Winter/summer season.
[4] Radial connection using 220 kV Zamosc-Dobrotvir line at the moment.
[5] Back-to-back connection

Table 6.29:
Cross-border interconnections development in January's reference point

## 6.30 PT – Portugal

### Generating Capacity

The Portuguese electricity system is currently characterised by high penetration levels of renewable energy, supplying more than 45% of total electricity consumption. The Portuguese strategy for energy development leads to an important growth of RES, mainly based on wind generation. Further, goals have been set for 2020, considering new pumped-storage hydro, wind and solar generation development.

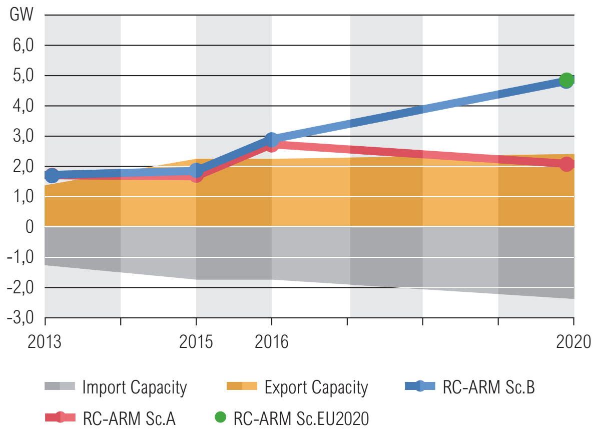


Figure 6.30:
RC-ARM Comparison Portugal,
Scenarios A, B and EU 2020, January 7 p.m.

Scenario EU 2020 is based on national energy policy drivers (to be released soon through a revised Portuguese NREAP), defined by the Portuguese government. Estimations under Scenario B support the same evolution of the Portuguese system. Main developments include the development of renewable energy sources until 2020, particularly wind power, reaching 5,300 MW as well as 3,535 MW of new large hydro power plants (2,660 MW equipped with pumping). The capacity installed in pumped-storage hydro power plants, along with the development of new interconnections, is of absolute importance to successfully compensating the volatility of intermittent generation from wind and solar. New already-licensed CCGT units total a capacity of 1,766 MW.

For Scenario A a conservative approach is used, meaning that no further generation capacity is assumed beyond the current system, only those added by firm known investments. Given this, there are no new thermal units considered until 2020 despite the decommissioning of a coal power plant. However, 2,125 MW of new (already-licensed) large hydro power plants are assumed along with some development of renewable energy sources (700 MW), particularly wind power.

### Unavailable Capacity

Non-Usable Capacity (under average conditions):

- Wind Energy – reflects the average unavailability of wind power (70 %);
- Hydroelectric energy (large power stations) – reflects the average lack of primary energy along with the incorporation of new mixed-pump power plants;
- Thermal RES and CHP (small independent producers) – reflects the average amount of capacity not being delivered to the grid, based on historical values.

Outages: The largest unit installed in the Portuguese system is assumed.

System Services Reserve: Secondary Reserve (including capacity to face interconnection capacity forecast uncertainties); 2 % of peak load (to face load forecast uncertainties).

### Load

The energy consumption forecast is based on estimations enabling compliance with the revised “National Action Plan for The Energy Efficiency”. This plan defines for the electric sector a total amount of savings of 5 % of consumption in 2015 and 10 % in 2020. No Load Management is assumed.

### Generation Adequacy

In the calculation of the Adequacy Reference Margin (ARM), Spare Capacity results from probabilistic adequacy studies which account for load supply in 99 % of the situations. According to the last four years of demand data, Margin Against Seasonal Peak Load is assumed to be 5 % and 4 % of peak load. This is so on the 3rd Wednesday of January at 7 p.m. and the 3rd Wednesday of July at 11 a.m., respectively.

In every analysed scenario, RC-ARM always remains positive.

### Interconnection Capacity

The Iberian Electricity Market (MIBEL) requires interconnection capacity in order to enable the required market energy exchanges, in both directions and with limited grid congestions.

REN and REE have been developing several projects (internal reinforcements and interconnections), which have allowed for the improvement of the interconnection capacity between Portugal and Spain from 550 – 850 MW in 2003 to 1,800 – 2,000 MW in 2011.

Despite this great increase, significant congestion still exists. To overcome this congestion, several investment projects, including two new 400 kV interconnections, are in progress. REN and REE have a common goal, namely to increase the NTC value to a range of around 3,000 MW[16].

The Iberian Peninsula has a very low interconnection exchange capacity with the rest of ENTSO-E. The reinforcement of the Spain-France interconnection will allow for an improvement of the quality and safety of supply, the growth of energy trade between the Iberian Peninsula and the rest of ENTSO-E. It will also allow for a greater and more efficient integration of renewable energy into the Iberian Peninsula system.

## 6.31 RO – Romania

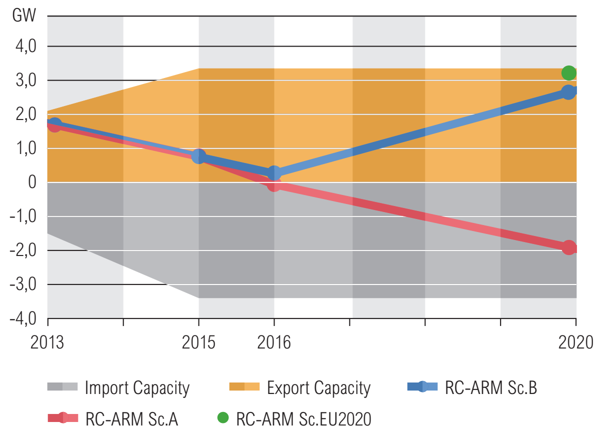


Figure 6.31:
RC - ARM Comparison Romania,
Scenarios A, B and EU 2020, January 7 p.m.

[16] For system adequacy purposes, Simultaneous Interconnection Transmission Capacity is based on 80 % of expected NTC between Portugal – Spain.

## 6.32 RS – Republic of Serbia

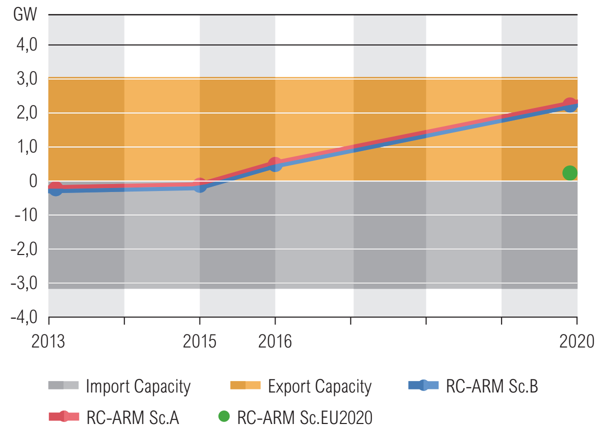


Figure 6.32:
RC - ARM Comparison Republic of Serbia,
Scenarios A, B and EU 2020, January 7 p.m.

## 6.33 SE – Sweden

### Generating Capacity

The following assumptions have been made to build **Scenario A** and **Scenario B**:

The NGC of nuclear power is expected to increase due to efficiency upgrades. In addition, it is assumed that a large increase of electricity generation from renewable sources is driven by the Swedish green certificates: the electricity certificate system. The increase of the power generation from renewable sources is expected to come primarily from biomass and wind power generation. The trend of refitting existing fossil fuel plants to biomass is expected to continue. Svenska Kraftnät has been notified of wind power projects with a total capacity of around 36 GW. Even though the main part of the planned wind power will probably not be built, the vast number of wind power plans is an indication of a large increase in wind power generation. The NGC of fossil fuels is expected to decrease.

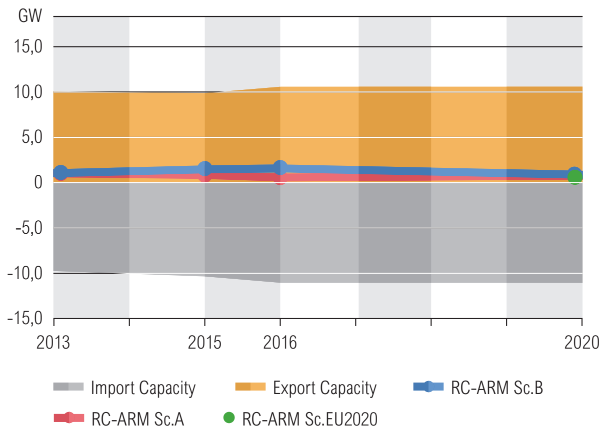


Figure 6.33:
RC - ARM Comparison Sweden,
Scenarios A, B and EU 2020, January 7 p.m.

The following assumptions have been made to build **Scenario EU 2020**:

A large increase of electricity generation from renewable sources is expected; mostly from biomass and wind power generation. In the Swedish NREAP the wind power generation in 2020 is relatively low, at 12.5 TWh. The wind power capacity in Sweden has dramatically expanded during the last years. At the end of 2011 the installed capacity of the wind power was 2,900 MW and the wind power generation during 2011 was around 6 TWh. Taking this development into consideration, a higher wind power generation of 14.5 TWh has been assumed in EU 2020. The generation of biomass CHP has been reduced as much as the wind power generation has been increased.

The following assumptions have been made regarding **Vision 1**:

One of the ten Swedish nuclear reactors is assumed to be decommissioned in Vision 1. Despite this assumption, the NGC of nuclear power is larger in Vision 1 than it is today due to efficiency upgrades. An increase of electricity generation from renewable sources is assumed to be driven by the Swedish green certificates: the electricity certificate system. The increase in the power generation from renewable sources is expected to come primarily from biomass and wind power generation. The NGC of fossil fuels is expected to decrease.

The following assumptions have been made regarding **Vision 3**:

The same assumptions as for Vision 1 have been made, with the exception of the following:

A large increase of electricity generation from renewable sources is assumed to be driven by the Swedish green certificates: the electricity certificate system.

The increase in power generation from renewable sources is expected to come mainly from wind power generation

## Unavailable Capacity

The following assumptions have been made to build **Scenario A**, **Scenario B**, **Scenario EU 2020**, **Vision 1** and **Vision 3**:

5 % of the NGC of nuclear power is assumed to be Non Usable Capacity both during summer and winter. Normally maintenance is carried out during summer when the demand is low. 5 % of the NGC of nuclear power is assumed to be unavailable due to maintenance during winter and 15 % during summer.

10 % of the NGC of fossil fuels and biomass is assumed to be Non Usable Capacity. Some "mothballed" fossil fuel plants are also included in the Non Usable Capacity. 5 % of the NGC of fossil fuels and biomass is assumed to be unavailable as a result of maintenance during winter. During summer approximately 15 % of the NGC for fossil fuels and biomass is assumed to be unavailable due to maintenance.

94 % of the NGC of wind power is assumed to be Non Usable Capacity. This assumption is made due to the variable and uncertain characteristics of the wind power generation.

2.5 GW of the NGC of hydropower is assumed to be Non Usable Capacity due to hydrological limitations.

## Load

The following assumptions have been made to build **Scenario A** and **Scenario B**:

Forecasts of the yearly electricity consumption are used as a reference value when the loads of the reference times have been approximated. Since 2008, the Swedish electricity consumption has been low due to the financial crisis, as electricity consumption is closely linked to economic activity. However, it should be mentioned that the Swedish electricity consumption has hovered around 135 – 150 TWh during the last decade whilst there has also been a trend of a non-growing consumption in Sweden even before the financial crisis. It is assumed that electricity consumption in 2013 will be 147 TWh. The economic situation is assumed to be better in 2015 and 2016 and therefore the demand is assumed to increase to 153 TWh. Thereafter, a lower annual average growth rate is chosen and the demand is only slightly increasing between 2016 and 2020.

Load management consists of load which can be disconnected. The Load Management data is based on the information found in the Swedish Government's proposal of a new legislation concerning Load Management. Historically, Svenska Kraftnät has been procuring reserve capacity for each winter season. This capacity is called the effect reserve (in Swedish: effektreserven). To harmonise the Swedish system with the European, the Swedish Government wishes to increase the share of load which can be disconnected in this Swedish effect reserve. In the winter of 2020/2021 the effect reserve is expected to be handled by the market.

The following assumptions have been made to build **Scenario EU 2020**:

The prognosis of the demand in the Swedish NREAP is used as reference value when the loads have been approximated.

With regard to load management, the same assumptions as in Scenario A and B are used for the EU 2020 Scenario.

The following assumptions have been made regarding **Vision 1**:

Forecasts of the yearly electricity consumption are used as a reference value when the loads of the reference times have been approximated. In Vision 1 the electricity consumption of the Swedish industry is assumed to decrease due to economic recession. The total electricity consumption during the year is assumed to be approximately 146 TWh.

The following assumptions have been made regarding **Vision 3**:

Forecasts of the yearly electricity consumption are used as a reference value when the loads of the reference times have been approximated. In Vision 3, the total electricity consumption during a year is assumed to be approximately 158 TWh. The increase in the electricity consumption is assumed to be driven by a large-scale introduction of electric vehicles and an increased consumption of the Swedish industry.

## Generation Adequacy

The following assumptions have been made to build **Scenario A** and **Scenario B**:

In Scenario A, the Adequacy Reference Margin is met by the Remaining Capacity (RC) in all years.

In Scenario B, the RC increases slightly until 2016 due to the increase of NGC of nuclear power, wind power and biomass. In 2020 the RC is decreasing somewhat, mainly due to the decommissioning of oil power plants. The ARM is always met by the RC in Scenario B. During summer time the ARM is well met by the RC, although during winter time the differences between RC and ARM are smaller. This means there is a larger need for import during winter and that there is room for export during summer.

The necessary Spare Capacity is assumed to be equal to the Frequency Controlled Normal Operation Reserve and the Frequency Controlled Disturbance Reserve described in the Nordic System Operation Agreement. In 2015, 2016, and 2020 the Spare Capacity is increased slightly.

The Margin Against Seasonal Peak Load is the difference between the load at the reference point and the peak load of the period the reference is a part of. The peak loads and the loads at the reference points are approximated from a load curve from 2007, up-scaled to the assumed demand.

The following assumptions have been made to build **Scenario EU 2020**:

The ARM is met by the RC in the Scenario EU 2020.

The same assumptions concerning spare capacity as in Scenario A and B are used for the EU 2020 Scenario. The Margin Against Seasonal Peak Load is calculated in the same way as in Scenarios A and B.

## Interconnection Capacity

The following assumptions have been made to build **Scenario A**, **Scenario B** and **Scenario EU 2020**:

The Simultaneous Import and Export Capacities are assumed to be the maximum Net Transfer Capacity (NTC). These capacities might be somewhat higher than the real Simultaneous Import and Export Capacities. In the beginning of 2016, Nord Balt is expected to be in operation.

## 6.34 SI – Slovenia

### Generating Capacity

NGC rises in all Scenarios also in Scenario A. The highest increase is expected for RES due to construction of solar PV and hydro units. A new lignite unit is under construction and will replace older units, hence no special increase in this category. Only Vision 3 predicts new NPP. The tables include 100 % of the existing NPP Krsko, although its ownership is equally divided between Slovenia and Croatia, thus half of its production is delivered to Croatia according to the international agreement.

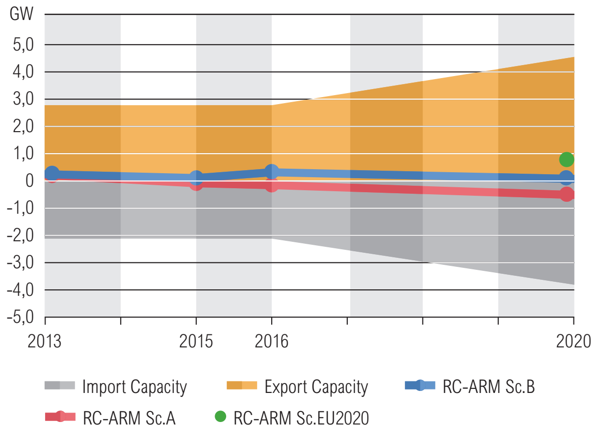


Figure 6.34:
RC - ARM Comparison Slovenia,
Scenarios A, B and EU 2020, January 7 p.m.

### Unavailable Capacity

Unavailable capacity mostly presents the non-usable capacity which is mainly the lack of primary sources for RES. The unavailable capacity is higher in winter than in summer reference point due to unavailability of solar PV at that time.

### Load

Slovenia is one of the countries with a major effect of the financial crisis on the GDP and thus on the electricity consumption and load. Economic growth is expected to be established after the year 2014; hence the load growth for the period 2015 – 2020 is expected to be the highest.

### Interconnection Capacity

Till 2030 the interconnection capacities will increase due to the new interconnection lines with Hungary and Italy and also due to reinforcements of the internal grid.

## 6.35 SK – Slovak Republic

### Generating Capacity

In Scenarios A, B and EU 2020 we consider two new power units as an extension of the existing nuclear power plant in Mochovce (this investment has already started). The capacity increase is expected to be approximately 880 MW, starting from 2014. In 2020 another increase is expected due to the generation efficiency enhancement processes (90 MW).

For the fossil fuels technology in Scenario A we expect a shut down of 400 MW in gas at the end of 2014 and a decrease of 200 MW in hard coal and 200 MW in lignite starting from 2016. In Scenarios B and EU 2020 we expect additional new gas capacity of 70 MW in 2015 and an additional 400 MW gas capacity in 2020.

With regards to the renewable technology we assume that for all Scenarios (A, B and EU 2020) the Slovak NREAP will be fulfilled as far as the energy targets are concerned, primarily installed capacity (because in some categories the target has been already met and will probably be exceeded, whilst in others it will only just be met). For hydro power plants only a small increase is expected as well, which is again due to the Slovak NREAP targets. Non-RES hydro category is currently not expected to increase.

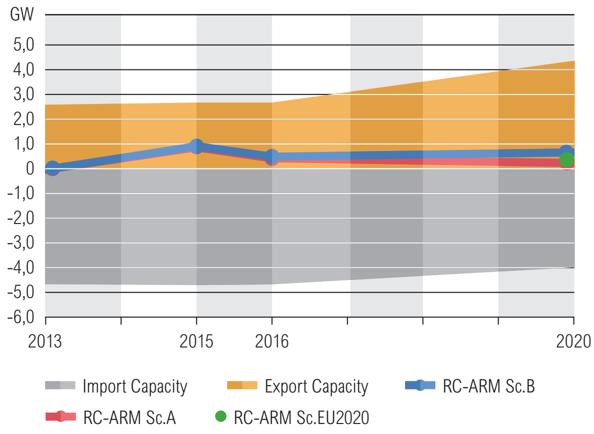


Figure 6.35:
RC - ARM Comparison Slovak Republic, Scenarios A, B and EU 2020, January 7 p.m.

For Vision 1 only an increase in the fossil fuels category for gas units is forecast. Compared to the year 2020, an additional 400 MW is expected in 2030, most probably in several smaller units (about 60 MW each) also considering minor shut down of older currently existing CCGT units. For renewable technology, only a minor increase is forecast for all categories focusing on the EU 2020 RES targets (according to the recommendation).

In Vision 3 only renewable sources are increased compared to Vision 1 – according to the recommendations, we forecast more optimistic RES development.

## Unavailable Capacity

In all Scenarios we take into account the RES unavailability for the winter period (wind and solar) whilst in the summer period these are mainly the operational regimes of CCGTs together with all the (smaller/higher) heating stations which also provide electricity generation. Maintenance, overhauls and system services reserve are estimated based on th historical experience. In all Scenarios RAC is sufficient to cover the expected load.

## Load

Load for Scenarios A and B is forecast the same and is in line with the annual national report on the results of the electricity supply security from the year 2012 (BAU Scenario). Load for Scenario EU 2020 is based on the Slovak NREAP. In Vision 3 the load again stems from the BAU Scenario of the report on the results of the electricity supply security from the year 2012, while the load in Vision 1 stems from the low scenario of the aforementioned report.

## Generation Adequacy

RC is expected to be positive in the main part of the investigated period. However, if the case of a negative RC occurs, it is only a minor value, and the import capacity of Slovakia is sufficient to cover potentially low generation from neighbours. In reality, however, imports are incurred by the behaviour of the market players who procure electricity from abroad due to the lower market prices, even if the available generating capacity in Slovakia could cover the demand smoothly. This is a long-term phenomenon of the Slovak transmission system or the Slovak electricity market.

## Interconnection Capacity

The Import/Export Capacities have been calculated as the maximum technical potential of the Slovak transmission system, not considering market limitations or operational margins. It must be mentioned that the values are very sensitive to the generation mix, the location of the generation units, the considered generation and transit flows. Therefore, these values must be treated very carefully and only as a rough/general information. These values of Import/Export Capacities are lower in real operations.

# 7 METHODOLOGY FOR SCENARIO OUTLOOK AND ADEQUACY FORECAST

# 7.1 System Adequacy

System adequacy of a power system is a measure of the ability of a power system to supply the load in all the steady states in which the power system may exist considering standard conditions. Within the ENTSO-E Scenario Outlook and Adequacy Forecast, system adequacy is assessed by means of Generation Adequacy Assessment.

The generation adequacy of a power system is an assessment of the ability of the generation in the power system to match the consumption of the power system. The methodology for generation adequacy analysis is introduced in Chapter 7.7.2.

# 7.2 Geographical Perimeter

System adequacy in ENTSO-E is analysed at 3 levels:

- individual ENTSO-E member countries[17];
- regional blocks;
- the whole ENTSO-E.

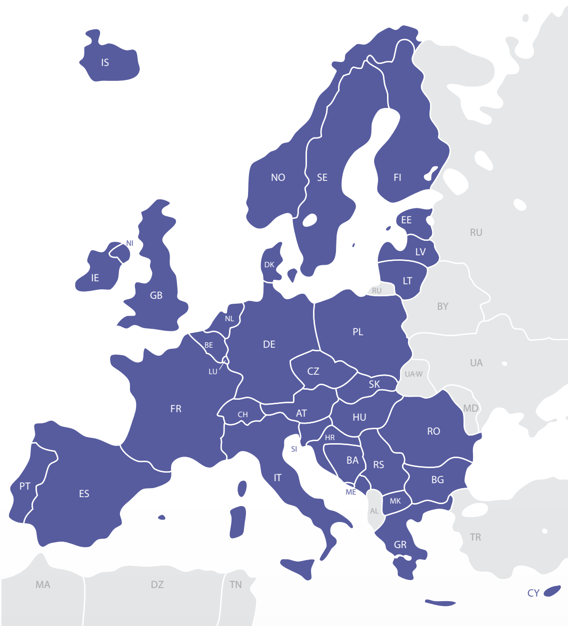


Figure 7.2:
ENTSO-E member countries

[17] While Albania and the Western part of Ukraine ("Burshtyn island") are part of the synchronous area, no data has been provided for the purposes of this report.

# 7.3 Forecast Scenarios

As long-term forecast is subject to a high level of uncertainty and considering that it can take several years to build a new power plant, two bottom-up generation Scenarios have been developed to help in assessing the range of uncertainty and to evaluate the risk for the security of supply over the coming years.

Besides these Scenarios, a Scenario EU 2020 compatible with the 3 × 20 objectives of the European Union (EU) has been developed. The purpose of this is to determine the generation outlook (renewable and conventional generation) which is necessary to reach the EU's 2020 targets. Scenario EU 2020 has therefore been built on the top-down principle using National Renewable Energy Action Plans[18)] (NREAP) as a reference for renewable energy sources and load determination. fossil fuels' forecast is envisaged to be built on the similar national documents reflecting the EU 2020 targets for the field of energy. For more information refer to paragraph 2.6.3.

For the 2030 time horizon, due to the uncertainties of such long-term forecasts, a different approach is taken; namely, data in this 2013 edition of SO&AF is collected for two distinctively different Visions, with the assumption that the actual future evolution of the assessed parameters would safely lie between the pathways of the two Visions.

Net Generating Capacity and the related primary energy sources breakdown as well as unavailable capacity are built in every country according to these generation Scenarios.

## 7.3.1 Conservative Scenario or Scenario A

This bottom-up Scenario shows the necessary additional investments in generation to be confirmed in the future. These are crucial in maintaining security of supply, if it is not already maintained.

This Scenario takes into account the commissioning of new power plants considered as sure and whose commissioning decision can no longer be cancelled (power plants under construction before the data collection or whose investment decision has been notified as firm to the correspondent company).

As far as decommissioning is concerned, the most likely shutdown of power plants expected during the study period should be considered. Official notifications cannot be the only source for this estimation. Therefore, an assessment of decommissioning based on additional criteria such as technical lifetimes is recommended. Load forecast in this Scenario is the best national estimate available to the TSOs, under normal climatic

18) http://ec.europa.eu/energy/renewables/transparency_platform/action_plan_en.htm

conditions. It is estimated according to technical, economic and political assumptions, especially on demography, economic growth and energy efficiency policy.

This Scenario is not used to further specify grid development as part of the Ten-Year Network Development Plan.

### 7.3.2 Best Estimate Scenario or Scenario B

This bottom-up scenario gives an estimation of potential future developments, provided that market signals give adequate incentives for investments.

This scenario takes into account the generation capacity evolution described in Scenario A as well as future power plants whose commissioning can be considered as reasonably credible according to the information available to the TSOs. Demands for grid connection by a producer cannot be the only source for this estimation. Therefore, an assessment regarding the likeliness of the projects, based on reasonable regional economic considerations of generation projects for instance, is expected in this scenario. Decommissioning and load should be treated as in Scenario A.

This Scenario is an important assumption when it comes to further specifying grid development in the Ten-Year Network Development Plan.

### 7.3.3 Scenario EU 2020

This top-down Scenario provides an estimation of potential future developments, provided that governmental targets set for renewable generating capacities in 2020 are met.

This Scenario is derived from the EU policies on climate change and is based on national targets set in the NREAP[19)] or equivalent governmental plan for renewable energy development if no NREAP applies. It takes into account the renewable generating capacities and electricity consumption mentioned in this plan.

A similar approach in the EU 2020 Scenario is taken as well as in the fossil fuels category, meaning that respective national policies/documents dealing with the future of fossil fuels generating units in the views of the EU 2020 goals are taken into account. If no such documents are available, the best TSO estimation is requested.

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19) Values in the SO&AF report might differ slightly from the original ones in NREAP, after their refinement through the communication between the ministries and TSOs to define the data delivered in accordance with general guidelines. The modifications are needed for various reasons: Values in the SO&AF document refer to net generation and net consumption while those within the NREAP refer to gross values, NREAP is based on energy instead of power values, whilst NREAP includes the whole country (including islands) and SO&AF may refer to mainland only, and so on.

This Scenario is an important assumption when it comes to further specifying grid development in the Ten-Year Network Development Plan and does not impose any limitation with regard to further possible renewable energy generation development.

## 7.3.4 2030 Visions

The year 2030 is used as a bridge between the European energy targets for 2020 and 2050. The aim of the "2030 Visions Approach" should be that the pathway realised in the future falls with a high level of certainty in the range described by the Visions that have been formulated taking into account the results of an extensive consultation, and which are detailed below.

The Visions are not forecasts and there is no probability attached to them. These Visions also have no adequacy analysis associated with them and are based on previous ENTSO-E and regional market studies, public economic analyses and existing European documents.

This is a markedly different concept from that taken for the three Scenarios until 2020, which aim to estimate the evolution of parameters under different assumptions, while the 2030 Visions aim to estimate the extreme values, between which the evolution of parameters is foreseen to occur. This conceptual difference is also stressed by the different presentation on graphs throughout this report.

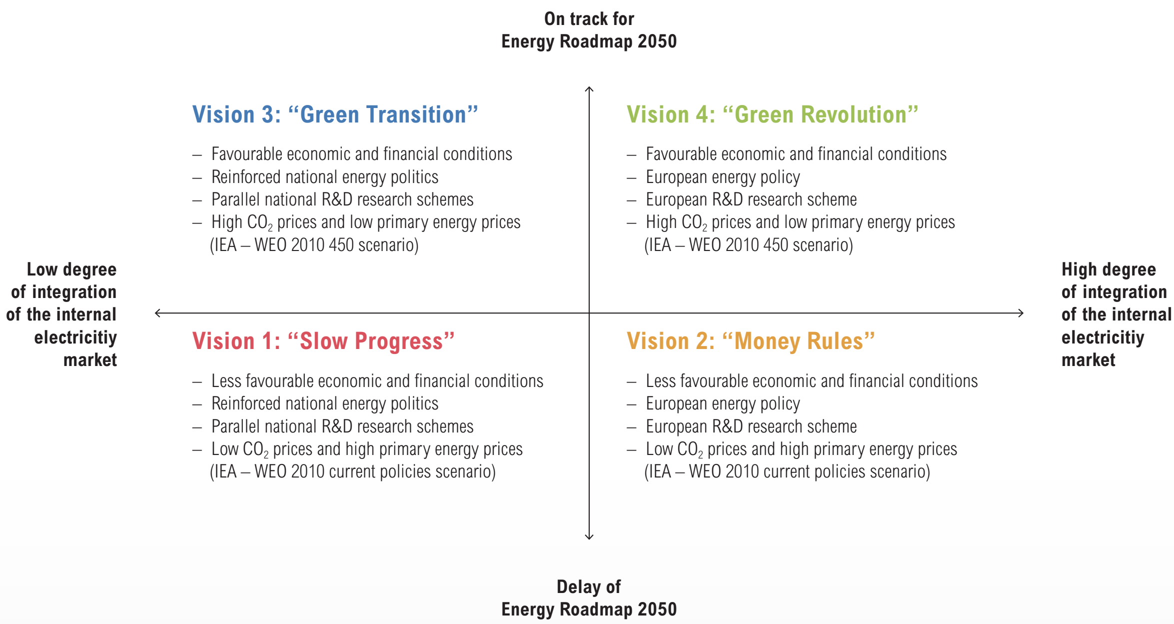


Figure 7.3.4.1:
Overview of the political and economic frameworks of the four visions

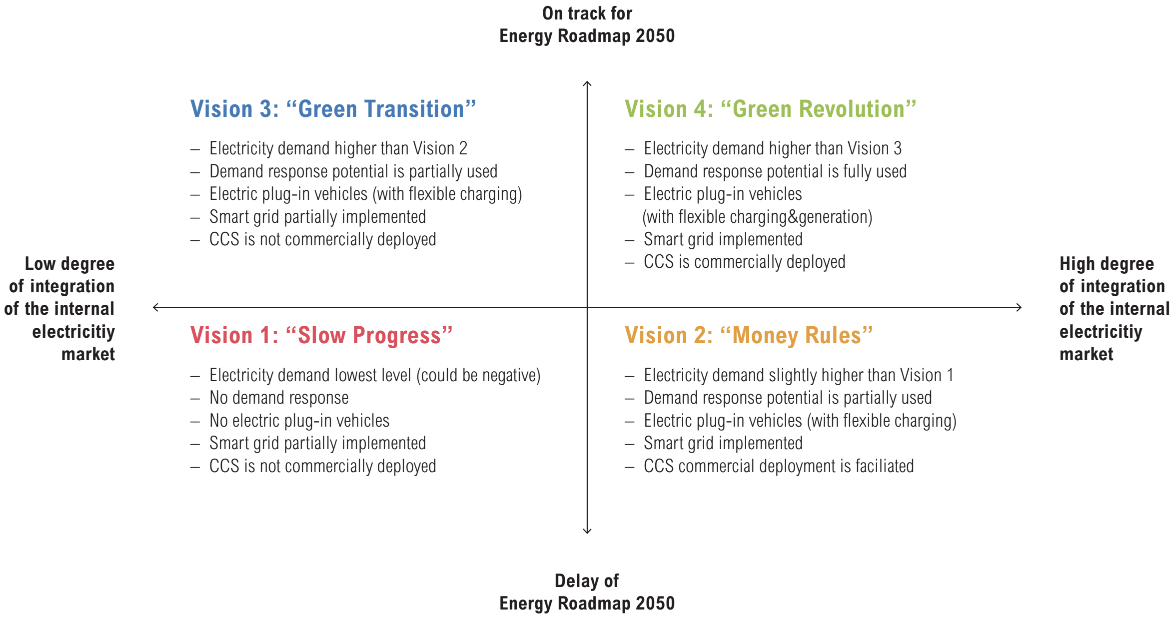


Figure 7.3.4.2:
Overview of the generation and load frameworks of the four visions

Differences in the high-level assumptions of the Visions are manifested among others in considerably higher $CO_2$ prices, but slightly lower (fossil) fuel prices in Vision 3, compared to Vision 1.

The bottom-up Visions 1 and 3 are included with quantitative data in this document, while the top-down Visions 2 and 4 are foreseen to be constructed by means of market studies and presented in detail in the TYNDP 2014 package.

## 7.3.4.1 Vision 1: "Slow progress"

### Economic and Market

The general framework of this Vision 1 "Slow progress" is that the economic and financial conditions are less favourable than in Visions 3 and 4 and. As a consequence of this, national governments have less money with which to reinforce existing energy policies. Furthermore, the absence of a strong European framework is a barrier to the introduction of fundamental new market designs which fully benefit from R&D developments. Moreover, the opting for parallel national schemes when it comes to R&D expenses also results in a situation where major technological breakthroughs are less likely due to suboptimal and repeated R&D spending.

Since no reinforcing of existing policies occurs, carbon pricing (e.g. the EU Emissions Trading System, carbon taxes or carbon price floors) remains at such a level that base load electricity production based on hard coal is preferred to gas. Carbon and primary energy prices could be based on the current policies scenario of the IEA in their WEO 2011. This means that countries with a lot of hard coal in their energy generation portfolio are likely to be net exporters.

### Demand

There are no major breakthroughs in energy efficiency developments (e.g. large-scale deployment of micro-cogeneration or heat pumps as well as minimum requirements for new appliances and new buildings) due to a lack of regulatory push. There are also no major developments in the usage of electricity for transport (e.g. large-scale introduction of electric plug-in vehicles) and heating/cooling. As a consequence, electricity demand is expected to grow at a slower rate than in the other visions (e.g. the growth rate of electricity demand could be negative here). Furthermore, no effort is made, through an adaption of the market design, to use the demand response potential which would allow for the partial shift of the daily load in response to the available supply.

### Generation

The future generation mix is determined by national policy schemes which are established without coordination at a European level. Due to a lack of financial resources and construction delays due to permitting issues, the generation mix in 2030 fails to be on track for the realisation of the energy roadmap 2050. If the energy objectives 2020 are only realised in 2030, the need for additional back-up capacity[20)] in 2030 would then remain at the same order of magnitude as that currently estimated for 2020. This back-up capacity is likely to come from gas units, since demand response potential and additional hydro storage are not significantly developed in this vision. However, due to the limited size of the back-up capacity, the need for flexible base load capacity remains reasonable and it is not likely that gas will push out hard coal for base load electricity generation.

This Vision also takes into account a growing public opposition to nuclear, despite it being a low-carbon technology, in the aftermath of the Fukushima Daiichi nuclear disaster. Nevertheless, the Vision permits deviations if this is in line with the current national view. In general, it is assumed that the financial community maintains its refusal to invest in this technology on a merchant basis and that technology-specific support schemes are not likely. The less favourable economic and financial conditions also result in the assumption that commercial deployments of Carbon Capture and Storage (CCS) infrastructure beyond the planned demonstration plants are not realistic.

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20) Besides the need for back-up capacity, other criteria also need to be taken into consideration when assessing how much dispatchable thermal generation should be assumed in a particular Visions, e.g. the yield of return based on a combination of running hours at full load and price mark ups allowing capital recovery.

### Grid

Distribution grid and transmission systems are today connected. There is a certain amount of price-elastic demand and smart communication enabling distributed resources to balance the RES fluctuation. However, it is assumed that this does not fundamentally change the load pattern. The impact of electric vehicles is also assumed to be negligible in this Vision (no commercial breakthrough of vehicles to grid connections).

## 7.3.4.2 Vision 3: "Green transition"

### Economic and market

The general framework of this Vision 3 "Green transition" is that the economic and financial conditions are more favourable than in Visions 1 and 2 and, as a consequence, national governments have money to reinforce existing energy policies. However, the absence of a strong European framework is a barrier to the introduction of fundamental new market designs which fully benefit from R&D developments. Furthermore, the opting for parallel national schemes regarding R&D expenses also results in a situation where major technological breakthroughs are less likely due to suboptimal and repeated R&D spending.

Since there is a reinforcing of existing energy policies, carbon pricing (e.g. the EU Emissions Trading System, carbon taxes or carbon price floors) reaches such levels that base load electricity production based on gas is preferred to hard coal. Carbon and primary energy prices could be based on the 450 scenario of the IEA in their WEO 2011. Gas is likely to push out hard coal for base load electricity generation. This means that countries with a lot of gas in their energy portfolio are likely to be net exporters.

### Demand

Efforts in energy efficiency developments (e.g. large-scale deployment of micro-cogeneration or heat pumps as well as minimum requirements for new appliances and new buildings) and the development of the usage of electricity for transport (e.g. large-scale introduction of electric plug-in vehicles) and heating/cooling are intensified to minimise the ecological footprint. However, these are developed in the current market frameworks. As a consequence, electricity demand is expected to grow at a faster pace than in Vision 1 "Slow progress" and Vision 2 "Money rules". This is due to the fact that the introduction of these new uses of electricity more than compensates for the realised energy efficiency improvements and is intensified through additional subsidies. Furthermore, the demand response potential is partially used to shift the daily load in response to the available supply, because it allows a saving on back-up capacity and is cheaper than storage.

### Generation

The future generation mix is determined by parallel national policy schemes which are on track to realise the decarbonisation objectives for 2050. However, it will be at a higher cost than it would be in the case of a strong European framework, since more back-up capacity is needed. The need for back-up capacity for intermitted renewable energy sources in Europe could be substantially more than the back-up capacity[21)] needed for the realisation of 3 × 20 objectives. This means that although demand response potential is used (50 % due to no fundamental change in market design), the majority of the additional back-up capacity in 2030 would come from gas units, since additional ways of central hydro storage are not developed due to the lack of a strong European framework. This vision also takes into account the growing public opposition to nuclear power, although it is a low-carbon technology, influenced by the aftermath of the Fukushima Daiichi nuclear disaster. Although the vision permits deviations if this is in line with the current national view, it is assumed that the financial community generally maintains its refusal to invest in nuclear technology on a merchant basis and that technology-specific support schemes are not likely. The absence of a strong European framework results in the assumption that commercial deployment of CCS infrastructure beyond the planned demonstration plants is not foreseen under the assumptions of this Vision.

### Grid

Distribution grid and transmission system connected as today. There is a certain amount of price-elastic demand and smart communication, enabling distributed resources to balance the RES fluctuation. However, it is assumed that this does not fundamentally change the height of the daily peak. The impact of electric vehicles is an augmentation of the load during off-peak hours.

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21) "Power Perspectives 2030: on the road to a decarburization power sector", European Climate Foundation (2011) mentions 5 times more back-up capacity (http://www.roadmap2050.eu/attachments/files/PowerPerspectives2030_FullReport.pdf).

## 7.4 Data Definitions

### 7.4.1 Time of Reference

Times in the SO&AF report are expressed in Central European Time (CET = UTC[22] +1) in winter, and in Central European Summer Time (CEST = UTC +2) in summer. All the data and analyses provided are in accordance with this approach.

### 7.4.2 Time Horizons

Data are collected for different time horizons and for different Scenarios. The time horizons per scenario will be mentioned in the data collection letter sent to the data correspondents from each TSO within ENTSO-E. Time horizons should copy the decades and mid-decades of upcoming years at least. Based on the data availability and accuracy, for the most part recommended time horizons for each scenario should not exceed Y+10 time period (where Y is the starting year of SO&AF report). However, when necessary or useful, the time horizons may go behind this 10 year border.

Aside from these time horizons, other time horizons might also be chosen in order to more thoroughly examine certain political milestones, for example. The total number of time horizons, however, is always chosen to not exceed the reasonable level of seriousness from the data accomplishing point of view.

### 7.4.3 Reference Points

Reference points are the dates and times data are collected for.

Data collected for the hour H are the average value from the hour H-1 to the hour H.

Two annual reference points are defined in the SO&AF report:

- The 3rd Wednesday of January at the 19th hour (from 18:00 CET to 19:00 CET)
- The 3rd Wednesday of July at the 11th hour (from 10:00 CEST to 11:00 CEST)

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[22] UTC is the international designation for Universal Coordinated Time

### 7.4.4 Load

Load on a power system is the net consumption corresponding to the hourly average active power absorbed by all installations connected to the transmission grid or to the distribution grid, excluding the pumps of the pumped-storage stations.

"Net" means that the consumption of power plants' auxiliaries is excluded from the Load, but network losses are included in the Load.

When load on the lowest voltage levels is not assessed, the National Representativeness index is the estimation of the percentage of the national value which the collected data are representative of.

### 7.4.5 Load Management

Load Management forecast is estimated as the potential load reduction under control of each TSO to be deducted from load in the adequacy assessment.

### 7.4.6 Net Generating Capacity

Net Generating Capacity (NGC) of a power station is the maximum electrical net active power it can produce continuously throughout a long period of operation in normal conditions. "Net" means the difference between, on the one hand, the gross generating capacity of the alternator(s) and, on the other hand, the auxiliary equipments' load as well as the losses in the main transformers of the power station.

If the lowest voltage levels are not considered for load (see 7.4.4), which is net of generation on these voltage levels, then the generation connected to these lowest voltage levels should not be reported. In this respect, the National Representativeness index (see 7.4.4) is the estimation of the percentage of the national value which the collected data are representative of. As generation adequacy is based on the comparison of national load and generation, National Representativeness of load data and generation data should be identical in order to make the generation adequacy assessment reliable.

Power plants and projects should be assigned to predefined categories.

### 7.4.7 Unavailable Capacity

Unavailable Capacity is the part of Net Generating Capacity which is not reliably available to power plant operators due to limitations of the output power of power plants. Although a power station can theoretically generate electricity from its total installed power, this is not actually the case in real life for the several causes, some of which are listed below.

It must be mentioned that RES is not always taken as equivalent to the conventional plants.

### 7.4.7.1 Non-Usable Capacity

Aggregate reductions of the net generating capacities are due to causes such as:

- Limitation due to intentional decision by the power plant operators;
  - Power stations in mothball which may be re-commissioned if necessary
  - Power stations bound by local authorities which are not available for interconnected operation
  - Power stations under construction whose commissioning is scheduled for a certain date, but capacity is not firmly available because of delays or retrofitting
  - Power stations which are converted to other fuels or which are subsequently equipped with desulphurisation and de-nitrification plants
  - Power stations in test operation

- Unintentional temporary limitation;
  - Power stations whose output power cannot be fully injected due to transmission constraints
  - Power station in multiple purpose installations where the electrical generating capacity is reduced in favour of other purposes such as heat extraction in combined heat and power plants for instance

- Temporary limitation due to constraints, like power stations in mothball or test operation, heat extraction for CHPs;

- Limitation due to fuel constraints management;
  - Nuclear power stations in stretch-out operation
  - Fossil fuel power stations
    - 1. Power stations with interruptible fuel supply
    - 2. Power stations with poor quality fuel, such as unfit coal

- Limitation reflecting the average availability of the primary energy source;
  - Hydro power stations
    - 1. Run-of-river power stations with usual seasonal low upstream water flow
    - 2. Tidal power stations
    - 3. Storage power stations subject to usual limitation such as limited reservoir capacity, power losses due to high water, loss of head height or limitation of the downstream water flow
  - Wind power stations;
  - Photovoltaic power stations;
  - Geothermal power stations;

- Power stations with output power limitation due to environmental and ambient constraints;
- Limitation due to other external constraints;
  - Hydro power stations with water flow regulation for irrigation, navigation, tourism
  - Power stations with output power limitation due to environmental constraints
  - Power stations with output power limitation due to external thermal conditions
- Etc.

#### 7.4.7.2 Maintenance and Overhauls

This category aggregates scheduled unavailability of generating capacity for regular inspection and maintenance.

#### 7.4.7.3 Outages

This category aggregates forced – that is, not scheduled - unavailability of generating capacity.

#### 7.4.7.4 System Services Reserve

This capacity is required to maintain the security of supply according to the operating rules of each TSO, excluding longer-term reserves set up to face potential outages which are counted in the Outages Category.

### 7.4.8 Peak Load

To extend the results from a unique reference point to a whole analysed period, ENTSO-E considers the Peak Load: one for summer and one for winter, both under normal conditions.

Peak load is the forecast maximum instantaneous value under normal conditions.

### 7.4.9 Margin against Seasonal Peak Load

Margin against Seasonal Peak Load (MaSPL) is the difference between Load at the reference point and the Peak Load over the season (summer or winter) which the reference point is representative of. It serves to extend the results from the single reference point to the whole investigated period.

Considering that load at each reference point is normally lower than the corresponding seasonal Peak Load, the values of MaSPL are expected to be non-zero.

### 7.4.10 Spare Capacity

Spare Capacity reflects the additional capacity (in MW) which should be available in a power system to cope with any unforeseen extreme conditions. It comes in addition to system services reserves and margin against seasonal peak load.

Spare Capacity should be sufficient to cover a 1 % risk of shortfall in a power system, that is, to guarantee operation in 99 % of the situations considering random fluctuations of load and the availability of generation units. By default, a value ranging from 5 to 10 % of net generating capacity could be used at a country-level. Since load/supply severe conditions of individual countries are not likely to occur on the same day or at the same time, Spare Capacity for a set of countries (regional blocks or whole ENTSO-E) will be expressed in the SO&AF report as 5 % of Net Generating Capacity.

### 7.4.11 Simultaneous Interconnection Transmission Capacities

The Simultaneous Interconnection Transmission Capacity (SITC) of a power system is the overall transmission capacity through its peripheral interconnection lines within ENTSO-E. SITC are calculated according to the ENTSO-E Regional Investment Plans.

The SITC export value is called Export Capacity and may differ from the SITC import value, which is referred to as Import Capacity.

Due to potential correlation between the transmission capacities on the adjoining borders of a country, it is not always possible to calculate the SITC of a country by simply adding the Net Transfer Capacity (NTC) on all the borders of the country.

SITC values are potentially different at every reference point on all time horizons.

## 7.5 Scenario Outlook Methodology

Further to an extensive presentation of the generating capacities, consumption and load in the three Scenarios as well as the bottom-up national 2030 Visions with emphasis on the most significant figures, comparisons could be made between these Scenarios.

When comparing Scenario B with Scenario EU 2020, the difference is shown between the amount of investments considered as likely by the TSO based on known projects. The investments needed to meet political targets for development of renewable energy are according to the National Renewable Energy Action Plan or equivalent governmental plan.

When comparing Scenario B with Scenario A, the idea is to show the difference in generation investments which have already been decided, with the amount of investment which is considered likely and needed by the TSO.

## 7.6 EU Energy Roadmap Indicators

In order to assess the compliance of the bottom-up national Visions with the 2050 roadmap goals of the European Commission, two very high level indicators are used to assess the quality of the collected visions before starting any modelisation, namely a RES and $CO_2$ indicators. A more precise indicator will be produced in the TYNDP 2014 when actual market simulations have taken place.

### 7.6.1 RES Indicator

The provided RES indicator is the ratio given by the generated power from Renewable Energy Sources (based on the simplified data of assumed equivalent full power hours (EFPH) by generation type) in a particular scenario in 2030. This is divided by the electric consumption of that particular scenario in 2030. The equivalent full power hours (EFPH) listed below are used as default value (in line with the methodology used in Pan-European Market Studies being carried out in the framework of the TYNDP 2014 process); however, specific values are used if delivered by national data correspondents.

**Energy = installed capacity X equivalent full power hours**

| | |
|---|---|
| All renewable hydro (except for Norway & Sweden) | 3900 h / year (but pumped storage) |
| All renewable hydro for Norway & Sweden | 4520 h / year (but pumped storage) |
| Onshore wind | 1900 h / year |
| Offshore wind | 3500 h / year |
| Solar | 1100 h / year |
| Biomass / Pellets & Waste | 5700 h / year |
| Other RES (Tidal, Waves, Geothermal) | 3000 h / year |

Table 7.6.1:
Generated power from Renewable Energy Sources in a particular scenario in 2030

## 7.6.1 $CO_2$ emissions indicator

Moreover, the European objective to cut greenhouse gases by at least 40 % of 1990 levels by 2030 needs to be translated to the electricity sector, since it is an objective for the whole economy. The translation to the power sector results in a European objective to cut greenhouse gases by at least 54 % of 1990 levels by 2030.

The proposed $CO_2$ indicator is a simplified approach which assumes that a representative average $CO_2$ content per MWh can be relied upon. The amount of $CO_2$ emission from electricity production is derived by multiplying the amount of electricity consumption not compensated by RES or nuclear production and a representative average $CO_2$ content per MWh.

The proposed indicator only reflects the $CO_2$ emissions resulting from the generation of electricity and does not include the other greenhouse gases which can be expressed as a $CO_2$ equivalent.

| GHG reductions compared to 1990 | 2005 | 2030 | 2050 |
|---|---|---|---|
| **Total** | **-7 %** | **-40 to -44 %** | **-79 to -82 %** |
| **Sectors** | | | |
| Power ($CO_2$) | -7 % | -54 to -68 % | -93 to -99 % |
| Industry ($CO_2$) | -20 % | -34 to -40 % | -83 to -87 % |
| Transport (incl. $CO_2$ aviation, excl. maritime) | +30 % | +20 to -9 % | -54 to -67 % |
| *Surface Transport* | *+25 %* | *+8 to -17 %* | *-61 to -74 %* |
| Residential and services ($CO_2$) | -12 % | -37 to -53 % | -88 to-91 % |
| Agriculture (Non-$CO_2$) | -20 % | -36 to -37 % | -42 to -49 % |
| Other Non-$CO_2$ emissions | -30 % | -72 to -73 % | -70 to -78 % |

Table 7.6.1:
EU targets for $CO_2$ emission reductions for 2050 roadmap goals

Furthermore, the indicator is a very rough estimation, since it is based on standard emission factors which are valid for the current generation technologies. Therefore, it only gives a very rough estimation and a prudent interpretation is advisable. Thus, a comparison is made with the emissions calculated for 2009 using these standard emission factors. In 2009, 49 % of the consumption not covered by RES or nuclear units is produced using coal or lignite. Furthermore, a range of possible reductions is estimated using two representative figures for the average $CO_2$ content per MWh, namely the average $CO_2$ content per MWh valid in 2009 (reference used for TYNDP 2012) and a $CO_2$ content per MWh. This assumes that consumption not converted by RES or nuclear units is covered with gas units.

- a multiplication of the generated power not from Renewable Energy Sources or nuclear generation (electric consumption – RES generation – nuclear generation) with a standard emission factor per MWh assuming an average internal content for thermal generation production of 0.36 t $CO_2$/MWh (which corresponds to 100 % gas).
- a multiplication of the generated power not from Renewable Energy Sources or nuclear generation (electric consumption – RES generation – nuclear generation) with a standard emission factor per MWh assuming an average internal content for thermal generation production of 0.68 t$CO_2$/MWh (which corresponds to average ratio for the output in 2009).

# 7.7 Adequacy Forecast Methodology

## 7.7.1 Power Balance

Power balance calculations concern specific time points and various parameters, with the aim of assessing adequacy referring to the following indicators:

- Reliably Available Capacity (RAC)
- Remaining Capacity (RC)
- Adequacy Reference Margin (ARM)

The relation between these three parameters is illustrated in figure 7.7.1.

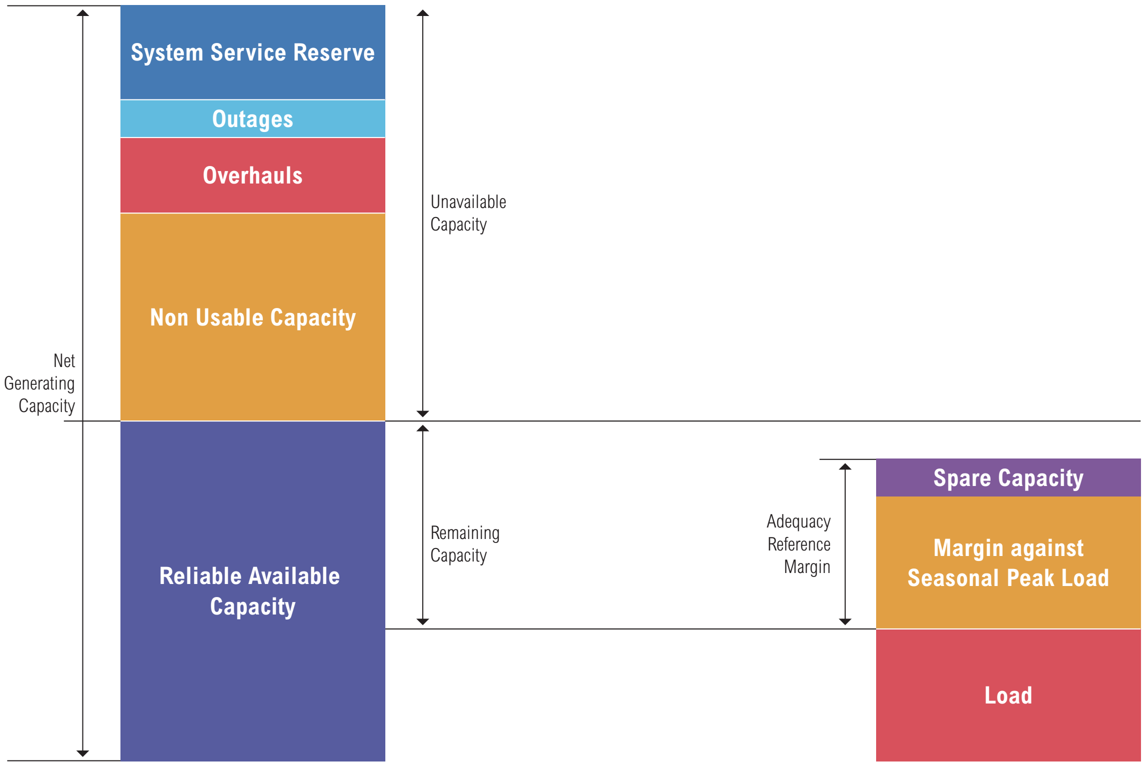


Figure 7.7.1:
Generation Adequacy Analysis

### 7.7.1.1 Reliably Available Capacity

Reliably Available Capacity on a power system is the difference between Net Generating Capacity and Unavailable Capacity.

Unavailable Capacity is the part of Net Generating Capacity which is not reliably available to power plant operators due to limitations of the output power of power plants. It is calculated by adding Non-Usable Capacity, Maintenance and Overhauls, Outages and System Services Reserves.

**Reliably Available Capacity** =
**Net Generating Capacity – Unavailable Capacity**

Reliably Available Capacity is the part of Net Generating Capacity which is actually available in the power system to cover the load at a respective Reference Point in normal (average) conditions.

### 7.7.1.2 Remaining Capacity

Remaining Capacity in a power system is the difference between Reliably Available Capacity and Load at reference point.

**Remaining Capacity** =
**Reliably Available Capacity – (Load – Load Management)**

Remaining Capacity is the part of Net Generating Capacity left in the power system to cover any unexpected load variation and unplanned outages at a Reference Point and in normal (average) conditions.

Remaining Capacity is calculated in the SO&AF report including Load Management, which increases the amount of Remaining Capacity.

#### 7.7.1.3 Adequacy Reference Margin

Adequacy Reference Margin is the part of Net Generating Capacity which should be kept available at all times to ensure that the security of supply on the whole period and each reference point which it is representative of. It serves to assess generation adequacy in most of the situations.

Adequacy Reference Margin in an individual country is equal to the sum of the Spare Capacity and the Margin against Seasonal Peak Load.

**Adequacy Reference Margin =**
**Spare Capacity + Margin against Seasonal Peak Load**

Adequacy Reference Margin in a set of countries (i.e. regional blocks or the whole ENTSO-E) is estimated as the sum of the two following terms:

- Sum of all individual Margin against Seasonal Peak Load values. As peak loads are not synchronous in all countries, this sum is overestimating the actual Margin against Seasonal Peak Load of the set of countries.
- Spare Capacity of the set of countries. This is estimated as 5 % of Net Generating Capacity of the set of countries. For this reason, Spare Capacity of the set of countries may be different from the sum of all individual Spare Capacity values.

Adequacy Reference margin for a set of countries is then given by following formula:

**n** is the total number of countries within the block of countries for which ARM is calculated;

**SC** is the abbreviation for "Set of Countries";

**IC** is the abbreviation for "Individual Country".

### 7.7.2 Generation Adequacy

Generation adequacy is assessed for each of the individual countries, for regional block(s) identified within the ENTSO-E system and for the whole ENTSO-E.

**Messages deriving from the assessment of generation adequacy may differ depending on the scenario which is under analysis. For "Conservative" Scenario A, the actual need for additional investments in**

**generation power is identified (or just the need for confirmation of projects which are not yet firmly engaged). Regarding "Best-Estimate" Scenario B, it is indicated how adequate investments are expected to be from an ENTSO-E point of view. A similar assessment for the EU 2020 scenario is conducted to establish whether the 202020-objectives and generation adequacy are compatible.**

#### 7.7.2.1 Generation Adequacy Forecast at Reference Points under Normal Conditions

Generation adequacy forecast on power systems is assessed at the reference points through the Remaining Capacity value (see definition in Chapter 7.7.1.2) which is calculated under normal conditions.

When Remaining Capacity is positive, this means that excess generating capacity is available in the power system under normal conditions.

When Remaining Capacity is negative, it means that the power system is short of generating capacity under normal conditions. Generally, this shall be interpreted as a potential deficit of generating capacity in power systems if no investments in additional generating units are decided from now until the analysed time horizon.

If the absolute value of a negative Remaining Capacity is lower than Import Capacity, it is likely that the full amount necessary to meet load can be imported. However, on the contrary (absolute value of negative) Remaining Capacity being higher than Import Capacity does not necessarily call for additional transmission capacities, as many uncertainties are present to size the adequate import capacity. These are not considered within the present report, but within Regional Investment Plans and the Ten Year Network Development Plan.

These assessments are applicable to individual countries, regional blocks and the whole ENTSO-E.

#### 7.7.2.2 Seasonal Generation Adequacy Forecast in Most of the Situations

Generation adequacy forecast in power systems is then extended to comprehend seasonal peak load as well as the occurrence of severe conditions. This is achieved through the comparison of Remaining Capacity and Adequacy Reference Margin.

When Remaining Capacity is equal to or higher than Adequacy Reference Margin, security of supply of power systems is likely to be guaranteed in most of the situations. Some of the excess generation capacity is likely to be exportable to other systems, even when severe conditions on both demand and supply sides occur.

When Remaining Capacity is lower than Adequacy Reference Margin, it means that the power system is likely to be reliant on imports when facing seasonal peak load and/or severe conditions. Generally speaking, this shall be interpreted as a potential deficit of generating capacity in power systems if no investments in additional generating units are decided from now until the analysed time horizon.

The (absolute value of) Remaining Capacity minus Adequacy Reference Margin being higher than Import Capacity does not necessarily call for additional transmission capacities, as many uncertainties are present in sizing the adequate import capacity. These are not considered within the present report, but within Regional Investment Plans and the Ten Year Network Development Plan.

When assessing the generation adequacy of regional blocks or whole ENTSO-E, a comparison made between Remaining Capacity and Adequacy Reference Margin still provides indications regarding potential surplus/deficits of regional blocks and whole ENTSO-E, as well as further eventual needs to additional investments in generating assets.

#### 7.7.2.2 Regional Analysis

As a new approach towards the intermediate level of adequacy assessment (i.e. between the national and pan-European level), a simplified optimisation study is carried out. This study identifies possible groups of countries relying on imports, instead of splitting the system according to the ENTSO-E regional groups. This new philosophy allows for a better identification and assessment of bottlenecks in the system, since the group(s) of countries analysed are chosen based on actual calculation results instead of forming regional groups first and performing regional assessment within the predefined country sets.

The above-mentioned optimisation study is based on the Remaining Capacity reduced by Spare Capacity (for definitions, refer to 2.6.1). Note that Margin against seasonal peak load is not taken into account in these calculations, as the peak load does not occur simultaneously in all countries. The optimisation attempts to cover the necessary import of all countries which have a negative RC-SC value, from those having a surplus of generation (positive RC-SC). During the calculation, the sum of cross-border flows is minimised, thus showing whether the required simultaneous imports of neighbouring countries are physically feasible and whether there is sufficient surplus available in other countries. This approach does not take into account market conditions. Both simultaneous and per-border transfer capacities (as in SO&AF and PEMMDB data entered by national correspondents, respectively) are observed in the calculation as boundary conditions.

The regional analysis is based on both reference points, data of Scenario EU 2020.

The results of the assessment and further details and explanations on the identified group(s) of countries requiring simultaneous imports are provided in paragraph 4.2.

### 7.7.3 Generation Adequacy Assessment Based on Probabilistic Studies

ENTSO-E is constantly looking for ways in which to improve the assessment of the European power system's adequacy. With the introduction of probabilistic modelling for the Ten-Year Network Development Plan 2012 (TYNDP 2012), new promising methods for adequacy assessment are within reach. Probabilistic modelling could potentially allow for many improvements in the adequacy assessment. For instance, improvements with respect to assessment of the adequacy value of (increased) transmission capacities.

Note however that ENTSO-E is still working on more detailed approaches to these questions, using historical data and probabilistic studies to assess the adequacy of a system in a more detailed and complex way. This part of the methodology will thus be updated accordingly in the future. As a first step to investigate the possibilities of Probabilistic Modelling Based Generation Adequacy Assessment methods, a few adequacy indicators (LOLE, EENS, etc.) extracted from the market studies carried out within the TYNDP 2012 process have been presented in the previous edition of the report. This 2013 issue does not update these indicators as the underlying studies are carried out biannually as part of the TYNDP process.

## 7.8 Other Important Facts/Information

All input data for this report have been provided by the TSOs (and their respective correspondents), on a national basis, for the years 2013, 2015, 2016, 2020 and 2030 (depending on the Scenario, see table below). Any other years depicted in graphs or shown in figures are calculated as linear extrapolations and are only estimations. The data collection process officially closes at the beginning of October 2012; however, after that date, substantial corrections and amendments of the database were made until the middle of December 2011 (corrections of mistaken data or complete providing missing data for some countries after deadline).

Furthermore, data provided for the time period after the year 2020 should be considered as having quite a high level of uncertainty. This results from data availability/unavailability to the respective TSO, along with the fact that many different national policies do not cover such a long-term period, etc. Therefore, a different approach is taken for the 2030 data, as explained in the Methodology section.

Data have been provided for the three Scenarios of generating capacity evolution (for more information see methodology document) and for two reference points: 3rd Wednesday of January 7 p.m. (for winter) and 3rd Wednesday of July 11 a.m. (for summer).

Data downloaded from the ENTSO-E Extranet and used for the SO&AF 2013 preparation are values rounded either to one decimal place (for main categories) or to two decimal places (for subcategories).

| Data collected | 2013 | 2015 | 2016 | 2020 | 2030 |
|---|---|---|---|---|---|
| Scenario A | x | x | x | X | |
| Scenario B | x | x | x | X | |
| Scenario EU20 | | | | X | |
| Vision 1 | | | | | X |
| Vision 3 | | | | | X |

Table 7.8:
Data collected

Calculations and comparisons used in the SO&AF 2013 to characterise the reliability of a power system are calculated mainly for the third Wednesday in January at 7 p.m. for Scenario B and Scenario EU 2020, unless otherwise indicated.

# Abbreviations

| | |
|---|---|
| **AC** | Alternating Current |
| **ACER** | Agency for the Cooperation of Energy Regulators |
| **CCS** | Carbon Capture and Storage |
| **CHP** | Combined Heat and Power Generation |
| **DC** | Direct Current |
| **EIP** | Energy Infrastructure Package |
| **ELF** | Extremely Low Frequency |
| **EMF** | Electromagnetic Field |
| **ETS** | Emission Trading System |
| **ENTSO-E** | European Network of Transmission System Operators for Electricity (see § A2.1) |
| **FACTS** | Flexible AC Transmission System |
| **FLM** | Flexible Line Management |
| **GTC** | Grid Transfer Capability (see § A2.6) |
| **HTLS** | High Temperature Low Sag Conductors |
| **HV** | High Voltage |
| **HVAC** | High Voltage AC |
| **HVDC** | High Voltage DC |
| **KPI** | Key Performance Indicator |
| **IEM** | Internal Energy Market |
| **LCC** | Line Commutated Converter |
| **LOLE** | Loss of Load Expectation |
| **NGC** | Net Generation Capacity |
| **NRA** | National Regulatory Authority |
| **NREAP** | National Renewable Energy Action Plan |
| **NTC** | Net Transfer Capacity |
| **OHL** | Overhead Line |
| **PEMD** | Pan European Market Database |
| **PCI** | Project of Common Interest (see EIP) |
| **PST** | Phase Shifting Transformer |
| **RAC** | Reliable Available Capacity |
| **RC** | Remaining Capacity |
| **RES** | Renewable Energy Sources |
| **RG BS** | Regional Group Baltic Sea |
| **RG CCE** | Regional Group Continental Central East |
| **RG CCS** | Regional Group Continental Central South |
| **RG CSE** | Regional Group Continental South East |
| **RG CSW** | Regional Group Continental South West |
| **RG NS** | Regional Group North Sea |
| **SEW** | Social and Economic Welfare |
| **SO&AF** | Scenario Outlook & Adequacy Forecast |
| **TSO** | Transmission System Operator |
| **TYNDP** | Ten-Year Network Development Plan |
| **VSC** | Voltage Source Converter |

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